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NGA STANDARDIZATION DOCUMENT

SENSOR INDEPENDENT DERIVED DATA (SIDD)

Volume 1

Design & Implementation Description Document

Specification for the design and implementation of SIDD data products.

(2019-05-31)

Version 2.0

NATIONAL CENTER FOR GEOSPATIAL INTELLIGENCE STANDARDS

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Date	Version	Description	DR/CA	Developer
01 AUG 2011	1.0.0	Initial publication.	N/A	
31 MAY 2019	2.0	Version number and effective date updated throughout the document. Contacts updated. XMLSpy static image diagrams replaced with metadata tables. Section 4.1 XML Metadata Types: updated Complex Types and Expanded Complex Primitive Types. Section 4.2 XML Metadata Parameter List: updated MatchInfo, Compression, and DED information; updated Display block display transformations; updated ExploitationFeatures geometry angle definitions; updated ValidData vertices field. Section 6 Display Calculations: updated enumeration types for display calculations. Section 7 ExploitationFeatures Calculations: updated Geometry angle definitions. Section 8 – Product Resolution: updated the Output plane definitions. Updates captured in this document break backward compatibility with SIDD v1.0.	N/A	

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FOREWORD

The suite of Sensor Independent Derived Data (SIDD) standardization documents describe the implementation of various data products generated by Synthetic Aperture Radar (SAR) systems and their data processing elements.

SAR-derived image products, and their associated metadata, are grouped around common tasks for downstream users. The SIDD documentation provides specifications for these common tasks which are designed to support basic exploitation, geographic measurements, and proper visual display. Additionally, the documentation specifies the SIDD supported coordinate systems and product image pixel arrays. The real utility of SAR image collection is in the products and measurements that may be derived from it. The quality of the pixel array data along with the set of metadata provided are critical in generating the derived products. The "sensor independence" of the SIDD product refers to the ability of the allowed pixel array and metadata options to accurately describe the image products from sensors and data processing systems. Sensor independence does NOT mean that all products have the same format for the pixel array or the same set of metadata parameters.

The SIDD documentation has been organized into three volumes:

Volume 1 is the description needed by producers of SAR data to design a SIDD product that contains the image data and the set of metadata that describe it.

Volume 2 defines the placement of SIDD data products in the NITF V2.1 image file format. Also provided is the description needed by users of SIDD products to read and properly extract the SIDD data components from a SIDD NITF product file.

Volume 3 defines the placement of SIDD data products in the GeoTIFF 1.0 image file format. Also provided is the description needed by users of SIDD products to read and properly extract the SIDD data components from a SIDD GeoTIFF product file.

A companion suite of standardization documents, collectively known as Sensor Independent Complex Data (SICD), describe standardized complex image products and measurements from which SIDD products may be derived.

The SICD and SIDD documentation and associated XML artifacts are available on the National System For Geospatial-Intelligence (NSG) Standards Registry (https://nsgreg.nga.mil).

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1 Introduction

1.1 Scope

The Sensor Independent Derived Data (SIDD) format is designed to store Synthetic Aperture Radar (SAR) derived-image products and their associated metadata, which is grouped around common tasks for downstream users. This document, the SIDD Design and Implementation Documentation (D&I), provides specifications for these common tasks which are designed to support basic exploitation, geographic measurements, and proper visual display. Additionally, this document specifies the SIDD supported coordinate systems and product image pixel arrays.

This document covers the following:

- Image pixel array definition
- Coordinate systems
- Primitive data types
- Extensible Markup Language (XML) schema definition
- Product metadata definitions
- Coordinate mapping models
- Display guidance

1.2 Capabilities & Limitations

The SIDD format is intended for image products only. Future revisions of the SIDD format may be expanded to other products. SIDD products are not required to be built from SICD inputs, but if they are, it is recommended that the unaltered SICD XML metadata be included. Consult program specific guidance. The SIDD metadata is intended to, but not limited to, support the following:

- Exploitation tool display
- Geographic measurements
- Library ingest & search
- Annotations

1.3 Sensor Specific Product Profiles

Each product/system has its own specifications and requirements for metadata. In order to meet these specifications, a set of metadata parameters is selected from the available SIDD metadata parameters. These parameters are referred to as the sensor-specific product profile and are contained in SIDD profile implementation documents.

1.4 Applicable Documents

The SIDD product design and implementation descriptions are contained in this and several other documents. The set of additional SIDD documents are listed in Table 1-1.

Table 1-1 SIDD Design Documentation		
Number	**Title**	**Date**
NGA.STND.0025-2_2.0	Sensor Independent Derived Data NITF File Format Description Document https://nsgreg.nga.mil/	31 MAY 2019 version 2.0
NGA.STND.0025-3_2.0	Sensor Independent Derived Data GeoTIFF File Format Description Document https://nsgreg.nga.mil/	31 MAY 2019 version 2.0
N/A	Sensor Independent Derived Data XML Schema (SIX Library) https://nsgreg.nga.mil/	31 MAY 2019 version 2.0.0

The SIDD product relies, when available, on the SICD product. The set of documents that describes the SICD product design is included in Table 1-2.

Table 1-2 SICD Design Documentation		
Number	**Title**	**Date**
NGA.STND.0024-1_1.2.1	Sensor Independent Complex Data Design & Implementation Description Document https://nsgreg.nga.mil/	13 DEC 2018 version 1.2.1
NGA.STND.0024-2_1.2.1	Sensor Independent Complex Data File Format Description Document https://nsgreg.nga.mil/	13 DEC 2018 version 1.2.1
NGA.STND.0024-3_1.2.1	Sensor Independent Complex Data Image Projections https://nsgreg.nga.mil/	13 DEC 2018 version 1.2.1
N/A	Sensor Independent Complex Data XML Schema	13 DEC 2018 1.2.1

A listing of other documents referenced by the D&I document is included in Table 1-3.

Table 1-3 Other Applicable Documentation		
Number	**Title**	**Date**
NGA.STND.0014_2.4	Softcopy Image Processing Standard	11 FEB 2015 Version 2.4
N/A	XML Schema Part 2: Datatypes http://www.w3.org/TR/xmlschema-2/	28 October 2004 1.0
ISO 19125-1:2004	Geographic information -- Simple feature access -- Part 1: Common architecture	2004 19125-1
N/A	Sensor Independent Common Data Types XML Schema	3 JUN 2010 1.0.0
NGA.STND.0012_2.0	National System for Geospatial Intelligence metadata Foundation (NMF) - Part 1: Conceptual Schema Profile, Version 2.0 https://nsgreg.nga.mil/doc/view?i=2142	16 December 2010
N/A	XML Data Encoding Specification for Information Security Marking Metadata,	As specified in NGA.STND.0012

	Note: Use of updated versions of IC ISM will be aligned with the currently published, and GEOINT community-adopted, version of NGA.STND.0012 A link to the ISM Metadata can be found at: https://www.dni.gov/index.php/who-we-are/organizations/enterprise-capacity/ic-cio/ic-cio-related-menus/ic-cio-related-links/ic-technical-specifications/information-security-marking-metadata	
ICC.1:2010-12	International Color Consortium	Dec 2010
STDI-0002-1_4.0	Compendium of Controlled Extensions (CE) for NITF, Volume 1, Version 4	1 August 2011

2 SIDD Image Pixel Array

The purpose of this section is to define the SIDD image pixel array, which is specified by the following items:

- Supported Pixel Types
- Visual Pixel Grid Layout
- Coordinate System

2.1 Supported Pixel Types

An image stored in the SIDD format may be represented as monochrome (8- or 16-bit), indexed color ("pseudo-color"), or 24-bit color. If the image is 8-bit monochrome or indexed color, the array will consist of byte values, each in the range of 0-255. For 24-bit data, each pixel will have three byte values in the range of 0-255, where the first byte indicates the red value, the second byte indicates the green value, and the third byte indicates the blue value.

In an indexed color pixel array, each byte represents an index into the color palette lookup table, rather than the actual pixel value. The lookup table contains a set of 256 triplet entries representing the red, green and blue values for a pixel, respectively.

The 8-bit monochrome data may also have a 256-entry lookup table mapping the byte into an output space that is between 8-bits and 16-bits.

2.2 Visual Pixel Grid Layout

The SIDD grid is defined in terms of rows and columns. The origin is zero-based and starts in the upper left corner. Movement toward the bottom of the image is defined to be in the increasing row direction and movement toward the right of the image is defined to be in the increasing column direction as shown in Figure 2-1 and Figure 2-2.

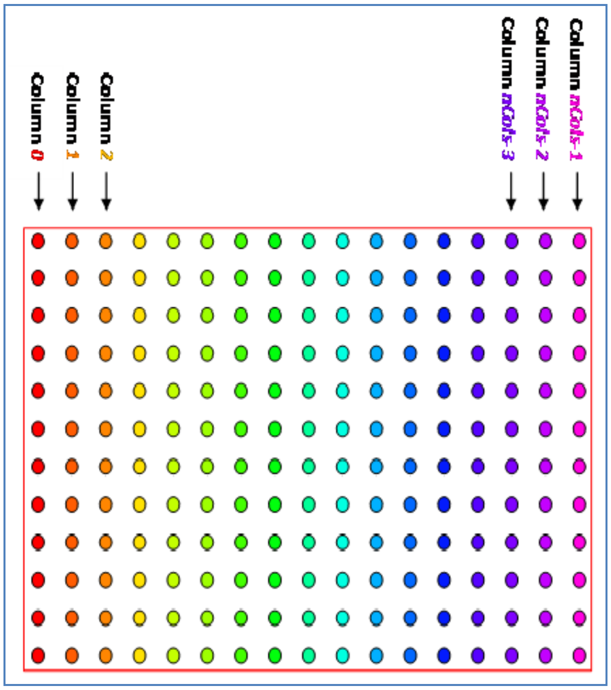


Figure 2-1 SIDD Column Grid Definition

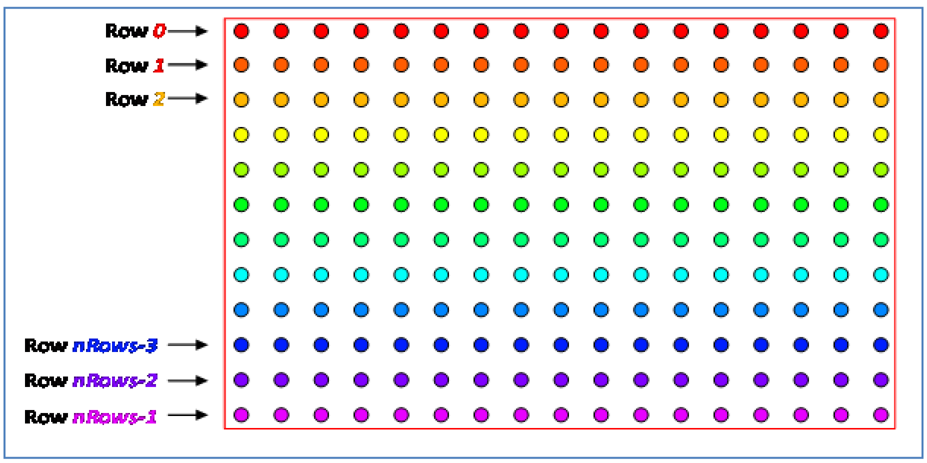


Figure 2-2 SIDD Row Grid Definition

All pixels in SIDD product pixels represent an area of data meaning that the integer pixel location is in the upper-left of the pixel and (0.5, 0.5) of the pixel is the middle of the pixel (See Figure 2-3). This was selected to conform to the NITF CCS and other standards.

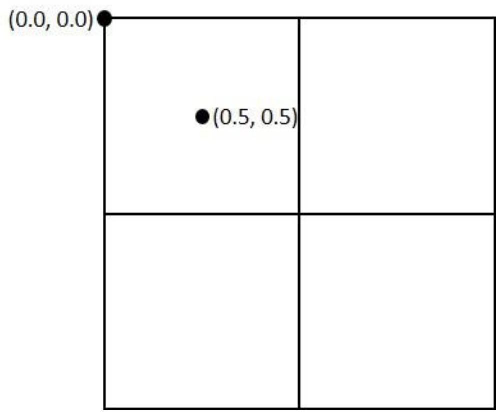


Figure 2-3 Pixel-is-area Diagram

2.3 Coordinate System

SIDD provides projection options for display of pixel amplitude data to four distinct representations: a Planar Gridded Display (PGD), Geodetic Gridded Display (GGD), Cylindrical Gridded Display (CGD), and Polynomial Fit Gridded Display (PFGD). These coordinate system layouts are intended for products which preserve the imaging geometry's layover. Furthermore, the grid layouts utilize constant sample spacing with respect to the underlying coordinate system; however, the row and column sample spacing can be unequal. The tables below provide variable definitions related to describing the PGD, GGD, CGD, and PFGD coordinate systems.

Table 2-1 Coordinate System Pixel Grid Variables

Variable Definition	**Definition**	**Units**
nRows	Number of rows in SIDD product image	Pixels
nCols	Number of columns in SIDD product image	Pixels
$\mathbf{P}_{PGD}$	Vector in Earth-Centered, Earth-Fixed (ECEF) coordinate system. Also sometimes shown as (X_0,Y_0,Z_0). Reference point for the PGD grid type.	Meters
$\mathbf{R}_{PGD}$	Unit vector defining the increasing visual row direction in the ECEF coordinate system	Unitless
$\mathbf{C}_{PGD}$	Unit vector defining the increasing visual column direction in the ECEF coordinate system	Unitless
$\mathbf{Z}_{PGD}$	Unit vector in the ECEF coordinate system orthogonal to $\mathbf{R}_{PGD}$ and $\mathbf{C}_{PGD}$, pointing out of the earth.	Unitless
Δ_r	Row pixel sample spacing	Meters/Pixel – PGD Meters/Pixel – CGD Arcsec/Pixel – GGD
Δ_c	Column pixel sample spacing	Meters/Pixel – PGD Meters/Pixel – CGD Arcsec/Pixel – GGD
r_0	Image grid row position corresponding to the scene center point	Pixels
c_0	Image grid column position corresponding to the scene center point	Pixels

Table 2-1 Coordinate System Pixel Grid Variables

Variable Definition	Definition	Units
$\mathbf{P}_{ECEF}$	Vector defining an arbitrary position in the ECEF coordinate system	Meters
r	Arbitrary row position in an image	Pixels
c	Arbitrary column position in an image	Pixels
λ	Longitude	Decimal Degrees
φ	Latitude	Decimal Degrees
h	Height above ellipsoid	Meters
$\mathbf{P}_{GGD}$	Reference point in a GGD pixel grid. Also referred to as $\{\varphi_0, \lambda_0, h_0\}$.	See λ, φ, and h
a	World Geodetic System (WGS)-84 semi-major axis = 6378137 meters	Meters
b	WGS-84 semi-minor axis = 6356752.31424518 meters	Meters
f	WGS-84 flattening factor = 1/298.257223563	Unitless
e_1	First eccentricity = $\sqrt{\frac{a^2-b^2}{a^2}}$	Unitless
e_2	Second eccentricity = $\sqrt{\frac{a^2-b^2}{b^2}}$	Unitless
R_c	Radius of curvature in the prime vertical = $\frac{a}{\sqrt{1-e_1^2 \sin^2 \varphi}}$	Meters
$\mathbf{P}_{CGD}$	Vector in ECEF coordinate system. Also sometimes shown as (X_{CGD},Y_{CGD},Z_{CGD}). Reference point for the CGD grid type.	Meters
$\mathbf{R}_{CGD}$	Unit vector defining the increasing visual row direction for the CGD grid type	Unitless
$\mathbf{C}_{CGD}$	Unit vector defining the increasing visual column direction for the CGD grid type	Unitless
$\mathbf{S}_{CGD}$	Unit vector defining the along stripmap direction in the ECEF coordinate system	Unitless
R_S	Radius used for the CGD projections	Meters

2.4 ECEF Coordinate System Definition

The origin of the ECEF coordinate system is at the center of mass of the Earth. The Z axis intersects the International Earth Rotation Service (IERS) Reference Pole. The X-axis intersects the IERS Reference Meridian and the plane passing through the origin and is normal to the Z-axis. The Y-axis completes a right-handed Cartesian coordinate system. The representation of the ECEF coordinate system is shown in Figure 2-4.

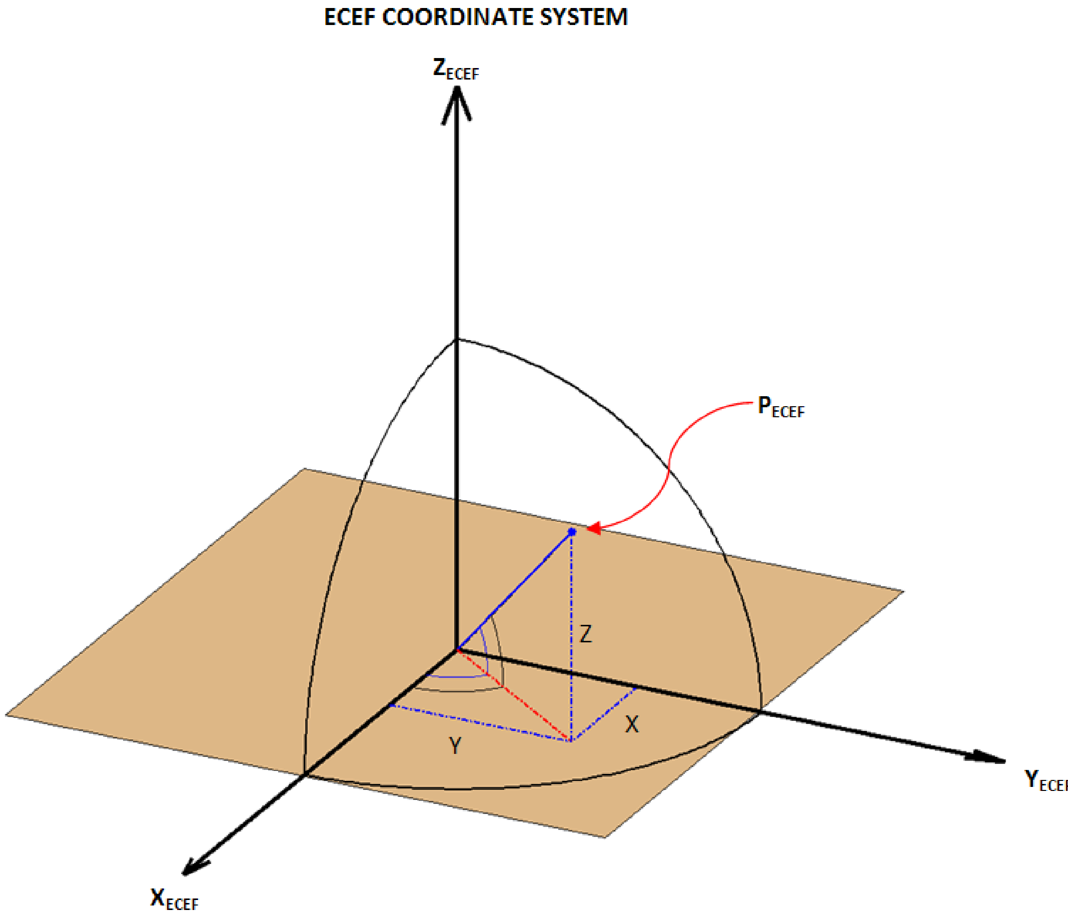


Figure 2-4 ECEF Coordinate System

2.5 Planar Gridded Display (PGD)

The Planar Gridded Display, PGD, shown in Figure 2-6, represents a row/column image sampled in a plane with constant sample spacing in the ECEF coordinate system. It is fully defined by an ECEF reference point, $\mathbf{P}_{PGD}$, and a vector normal to the plane, $\mathbf{Z}_{PGD}$. The two in-plane vectors define movement in the increasing row direction, $\mathbf{R}_{PGD}$, and the increasing column direction, $\mathbf{C}_{PGD}$, and are orthogonal. The in-plane vector relationship to the grid layout is shown in Figure 2-5. It is recommended that projection to this grid be performed such that the resulting image is "shadows-down", if possible.

The row and column sample spacing, Δ_r and Δ_c respectively, define the relationship between PGD pixel space and physical linear measurements in meters. $\mathbf{P}_{PGD}$ is the PGD reference point associated with the row and column, r_0 and c_0.

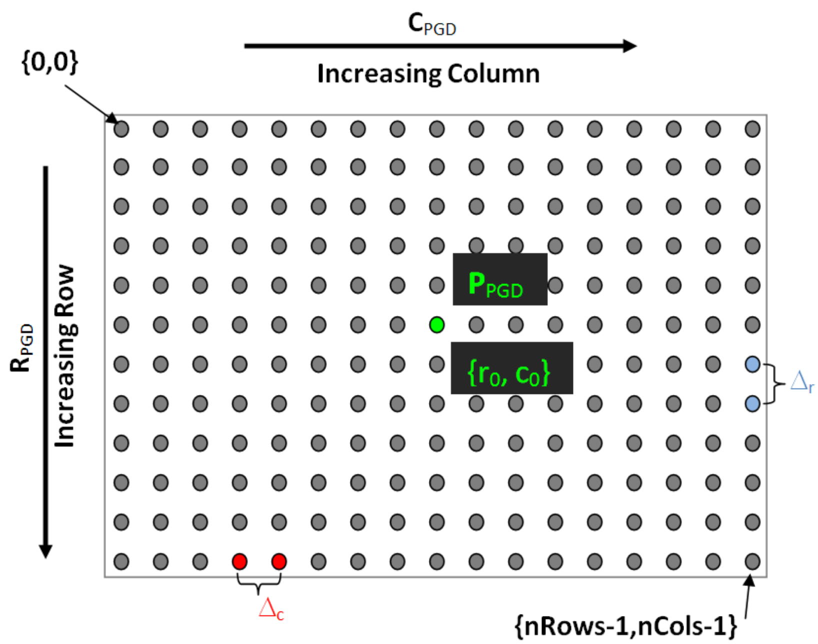


Figure 2-5 PGD Gridded Display

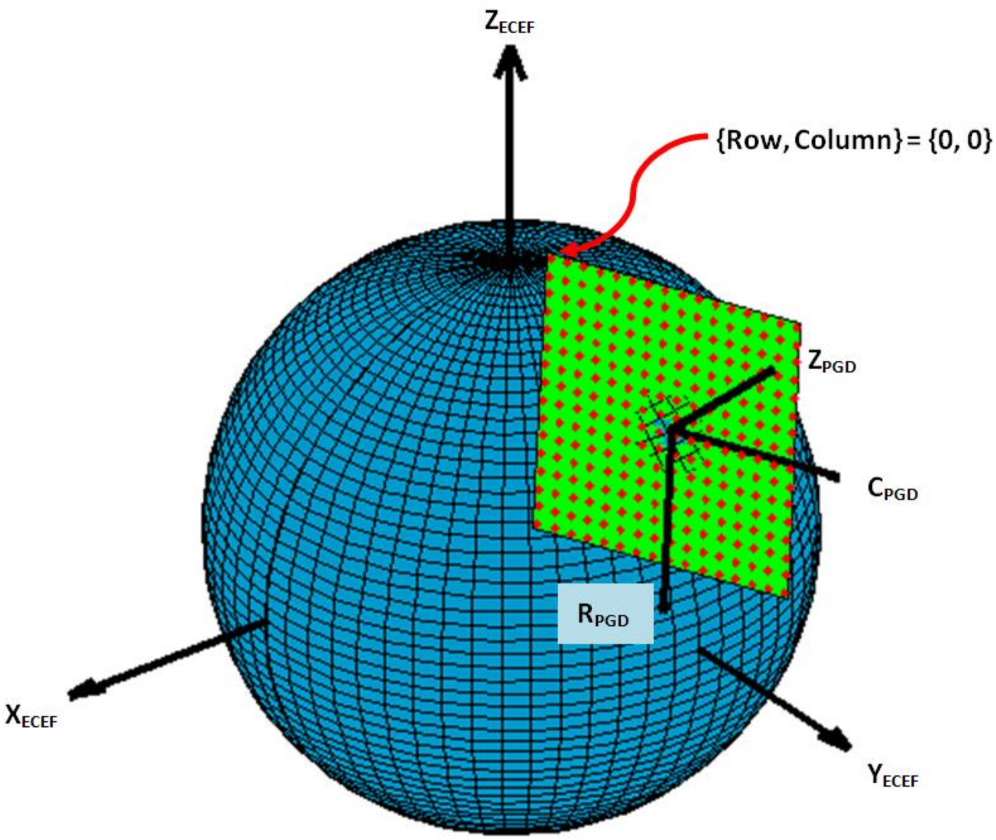


Figure 2-6 PGD Example

2.6 Geodetic Coordinate System Definition

The geodetic coordinate system shown in Figure 2-7 is based on latitude, longitude, and height above an ellipsoid and an ellipsoid model. The ellipsoid model used for SIDD is the WGS-84 ellipsoid model. The equator and prime meridian define the zero values for latitude and longitude, respectively. Geodetic latitude is the angle between the equatorial plane and a line that is normal to the reference ellipsoid.

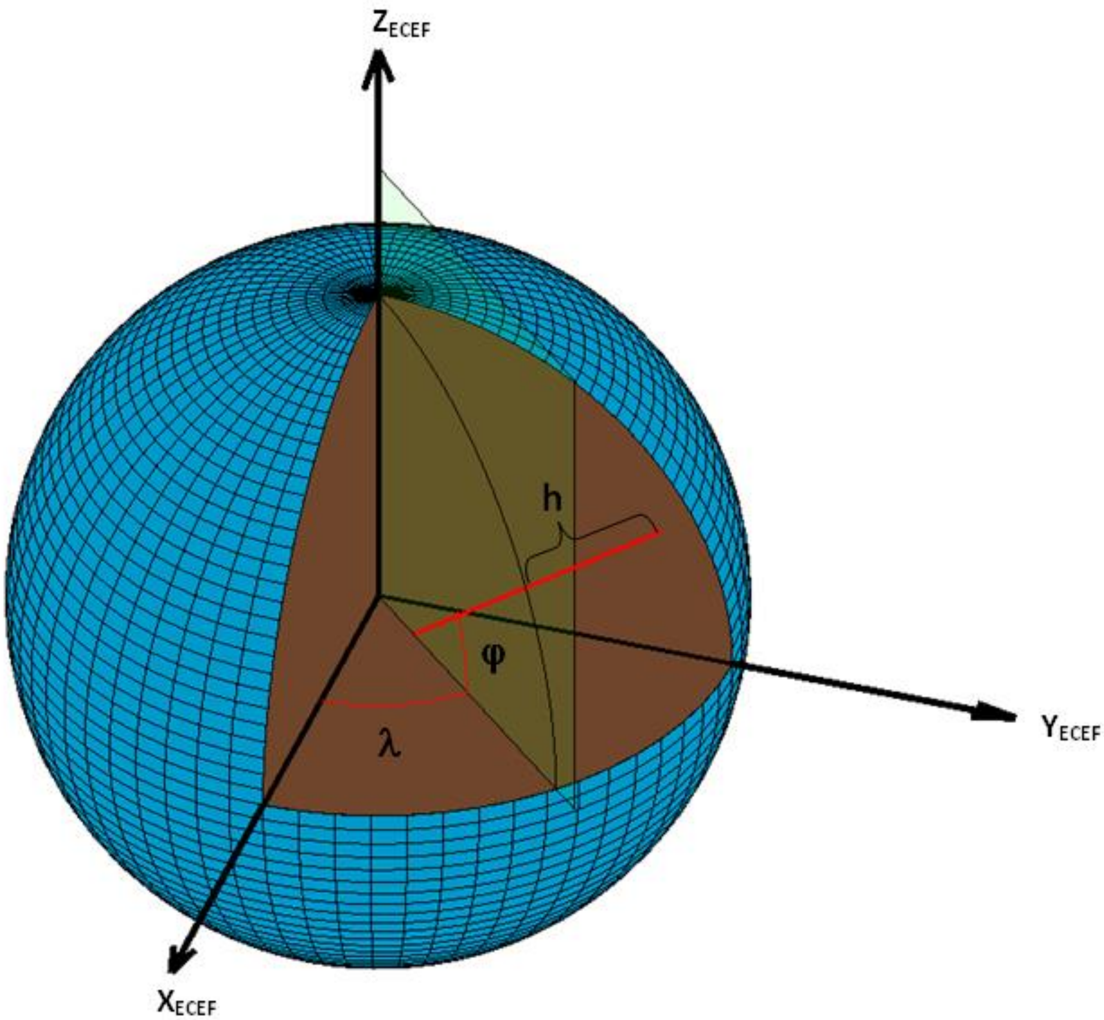


Figure 2-7 Geodetic Coordinate System

2.7 Geodetic Gridded Display (GGD)

The Geodetic Gridded Display, GGD is a row/column image coordinate system (see Figure 2-8) and has an associated set of geodetic coordinates, which are expressed by latitude, longitude, and height (see Figure 2-9). The GGD is fully defined by a geodetic reference point, $\mathbf{P}_{GGD}$, and the WGS-84 ellipsoid model.

The row and column sample spacing, Δ_r and Δ_c respectively, define the relationship between GGD pixel space and angular measurements, e.g. arc seconds. The association with the geodetic reference point, $\mathbf{P}_{GGD}$, is a particular GGD row and column, r_0 and c_0. An adjustment in either row or column pixel location is represented by a corresponding adjustment in latitude and longitude. Each image coordinate is thus directly associated with a geodetic latitude and longitude.

For image footprints which are not aligned in latitude and longitude, for which the elimination of the surrounding black-fill is desired, the *GeometricChip* metadata can be used to represent the rotation of the grid space (Section 0).

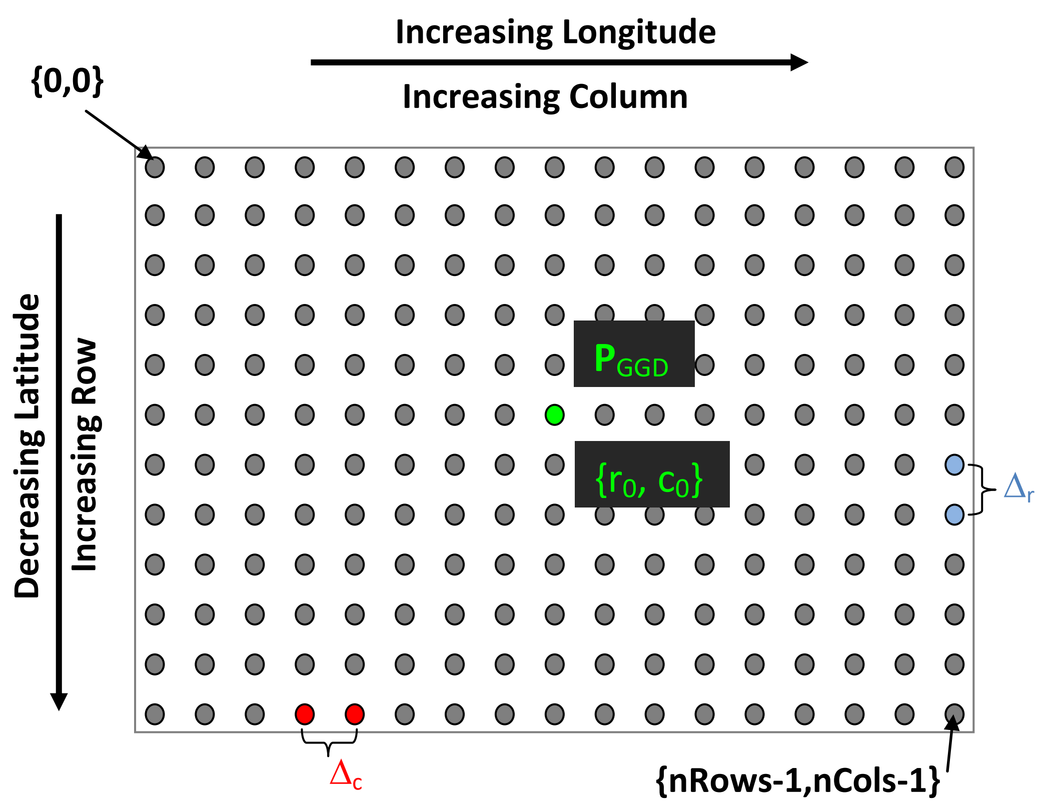


Figure 2-8 Geodetic Gridded Display

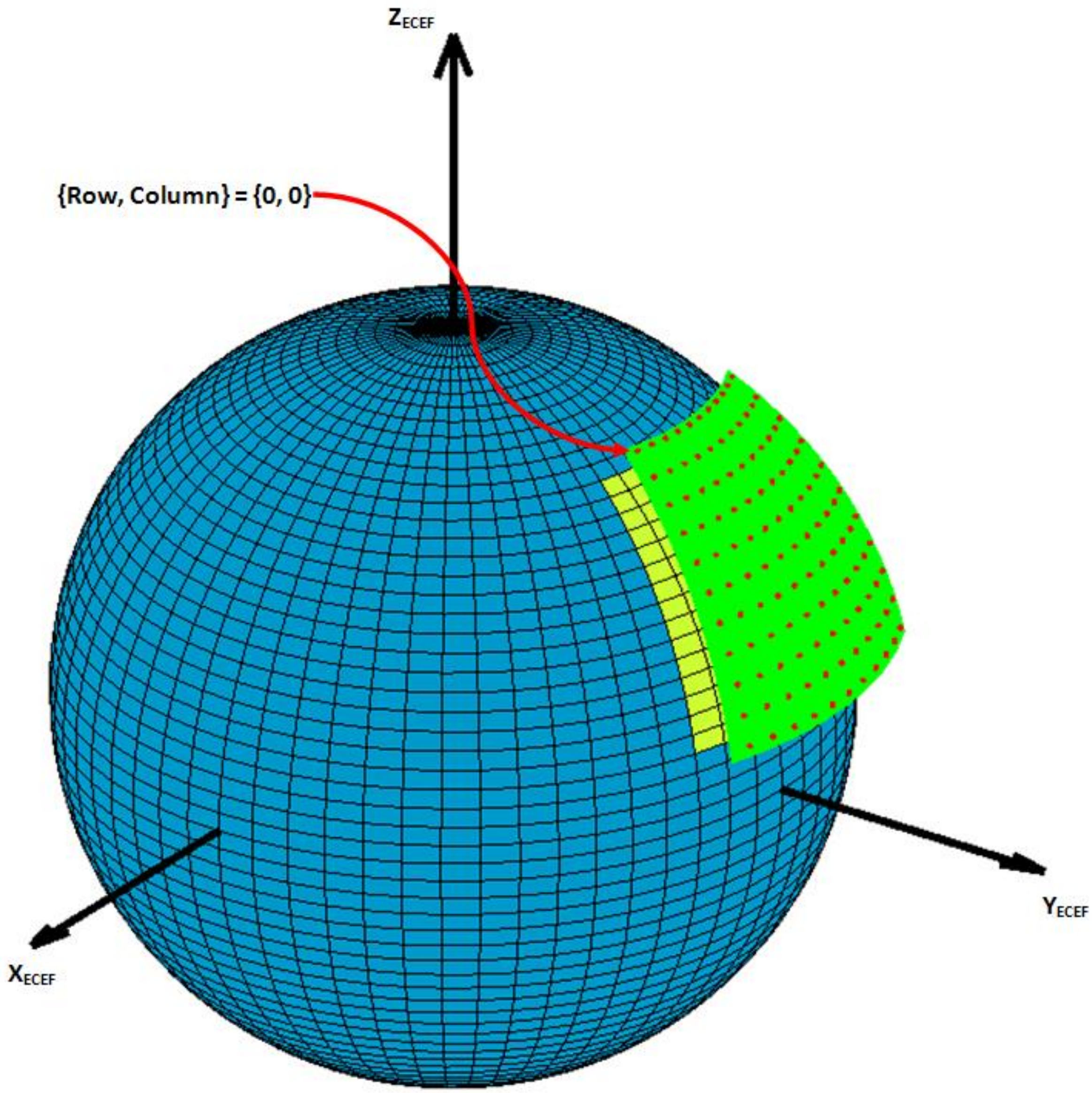


Figure 2-9 GGD Example

2.8 Cylindrical Gridded Display (CGD)

The Cylindrical Gridded Display represents an image sampled on a cylindrical surface. This grid type is useful when the imaging mode is (dynamic) stripmap and mapping on the PGD would result in large image distortions. The cylinder's axis is parallel to the cross-stripmap direction and the cylinder's radius is designed to match an inflated WGS-84 ellipsoid. Note that this inflated ellipsoid is only used to determine the cylinder's radius; the pixels themselves do not lie along an inflated ellipsoid.

The CGD (Figure 2-10 and Figure 2-11) is fully defined by a CGD reference point, $\mathbf{P}_{CGD}$, a cylinder radius, R_s, and the along stripmap direction, $\mathbf{S}_{CGD}$. If a cylinder radius is not supplied, then a radius is computed by an inflated ellipsoid. The row and column sample spacing, Δ_r and Δ_c respectively, define the relationship between CGD pixel space and linear distance. Unlike the PGD, where $\mathbf{R}_{PGD}$ and $\mathbf{C}_{PGD}$ are allowed to be in any orientation, the CGD basis vectors are constrained to one orientation; $\mathbf{R}_{CGD}$ is aligned in the cross-stripmap direction and $\mathbf{C}_{CGD}$ is in the along-stripmap direction.

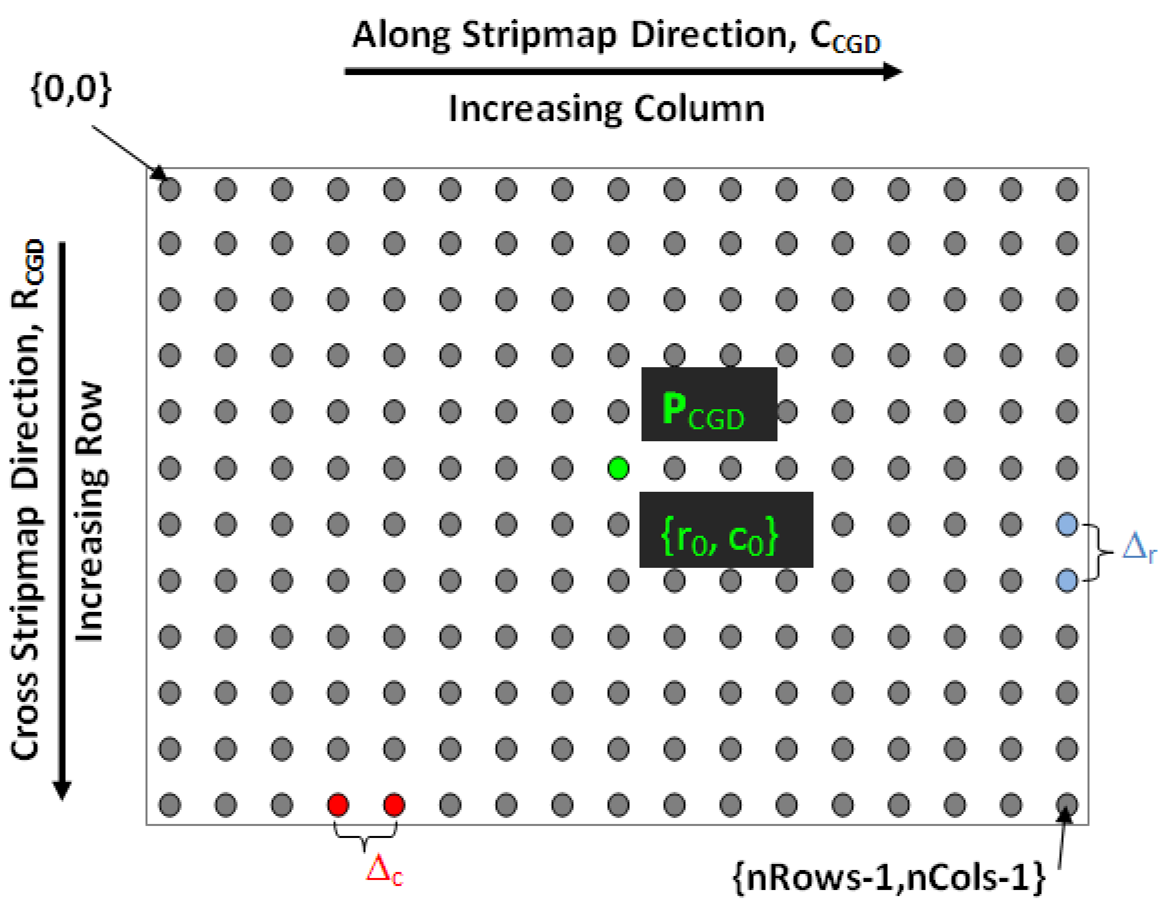


Figure 2-10 CGD Image Example

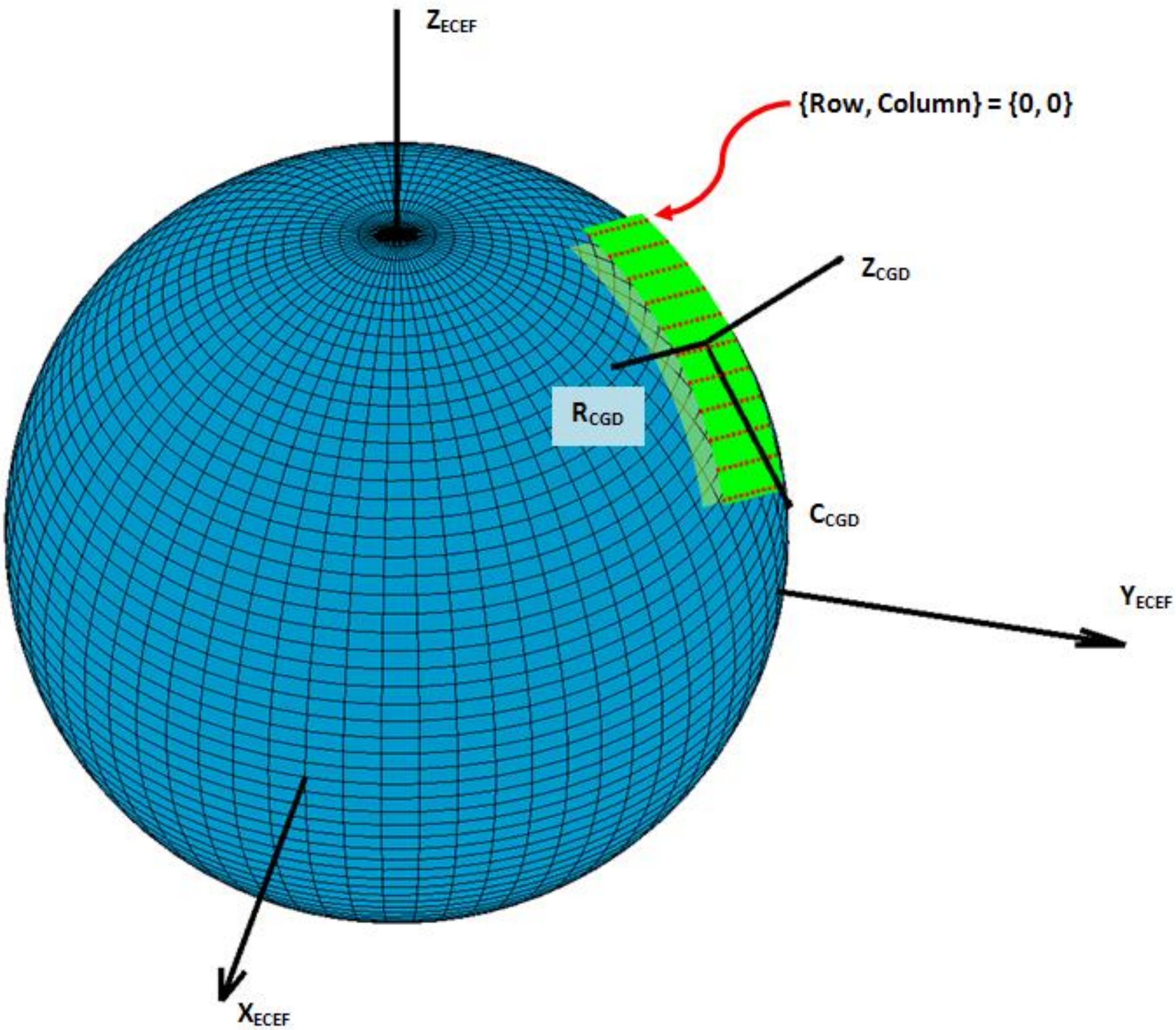


Figure 2-11 CGD Example

2.8.1 CGD inflated ellipsoid

The inflated ellipsoid has the same shape as the WGS-84 ellipsoid model but with a modified equatorial radius. The new equatorial radius is computed so that $\mathbf{P}_{CGD}$ is on the inflated ellipsoid. The computation for the inflated ellipsoid equatorial radius is as follows:

$$a' = \sqrt{\left(X_{CGD}^2 + Y_{CGD}^2 + \frac{Z_{CGD}^2}{(1-f)^2}\right)}$$

The modified geodetic coordinates are computed below:

$$\lambda' = \lambda$$

$$\varphi' = \tan^{-1}\left(\frac{Z_{CGD}}{(1-f)^2\sqrt{X_{CGD}^2 + Y_{CGD}^2}}\right)$$

Note that this equation is correct if and only if the ECEF point (X_{CGD}, Y_{CGD}, Z_{CGD}) lies on the ellipsoid. The ECEF point can be assumed to lie on the ellipsoid for the CGD case.

2.8.2 Modified Local East, North, Up Coordinate system

The inflated ellipsoid necessarily changes the direction of the east, north, and up directions. These bases must be recomputed at the modified geodetic coordinates.

$$\begin{aligned}
\boldsymbol{E}' &= [-\sin\lambda' \quad \cos\lambda' \quad 0] \\
\boldsymbol{N}' &= [-\sin\varphi'\cos\lambda' \quad -\sin\varphi'\sin\lambda' \quad \cos\varphi'] \\
\boldsymbol{U}' &= [\cos\varphi'\cos\lambda' \quad \cos\varphi'\sin\lambda' \quad \sin\varphi']
\end{aligned}$$

2.8.3 CGD Bases computations

The CGD bases need to be in a plane that is tangent to the inflated ellipsoid. Given a (dynamic) stripmap direction, $\mathbf{S}_{CGD}$, the CGD bases are computed below:

$$\alpha = \tan^{-1}\frac{\boldsymbol{E'}\cdot\boldsymbol{S}_{CGD}}{\boldsymbol{N'}\cdot\boldsymbol{S}_{CGD}}$$

$$\begin{aligned}
\boldsymbol{C}_{CGD} &= \cos\alpha\,\boldsymbol{N}' + \sin\alpha\,\boldsymbol{E}' \\
\boldsymbol{R}_{CGD} &= \boldsymbol{C}_{CGD} \times \boldsymbol{U}'
\end{aligned}$$

2.8.4 Modified Radius of Curvature in the Meridian

The radius of curvature in the North-South direction at a specified latitude is shown below:

$$R_N = \frac{a'(1-e_1^2)}{(1-e_1^2\sin^2\varphi')^{1.5}}$$

2.8.5 Modified Radius of Curvature in the Prime Vertical

The radius of curvature in the East-West direction at a specified latitude is shown below:

$$R_E = \frac{a'}{\sqrt{1-e_1^2\sin^2\varphi'}}$$

2.8.6 Radius of Curvature in the Along Stripmap Direction

The radius of curvature in the along-stripmap direction is computed below; this is equivalent to the cylinder's radius:

$$\frac{1}{R_S} = \frac{\cos^2\alpha}{R_N} + \frac{\sin^2\alpha}{R_E}$$

Note that the radius of curvature R_S, derived above, should be utilized with the CGD unless a different one is provided in the XML metadata.

2.9 Polynomial Fit Gridded Display (PFGD)

The Polynomial Fit Gridded Display (PFGD) is an arbitrary surface which can be represented by a polynomial. The PFGD metadata provides for an approximation to the rigorous projection models. *If a sensor's metadata supports creation of a rigorous geometry model, then one of the previous grid types should be used instead of the Polynomial Fit Gridded Display. This model is reserved for backwards compatibility with systems that do not provide the metadata necessary for a rigorous projection.* The approximation uses a set of polynomials which expresses row and column pixel locations as a function of latitude and longitude. In addition, a set of polynomial approximations are included in PFGD to express latitude, longitude and an approximate height as a function of row and column pixel locations.

3 Coordinate Transformations

The image formation process generates a two-dimensional projection of the three-dimensional imaged scene. Each resolution cell is a combination of a range/range-rate projection (see *Sensor Independent Complex Data Image Projections*) and image formation algorithm dependent geometrical distortions. The goal of the SIDD grids is to remove all image formation algorithm dependent geometrical distortions; however, it is ultimately up to the end user to determine the ideal grid for exploitation. It is important to emphasize that the PGD, GGD, CGD, and PFGD coordinates defined in Section 2 are not necessarily terrain surface locations. In order to determine accurate terrain surface locations, knowledge of the underlying terrain must be provided (via a priori terrain height information).

Section 3.1 describes the difference between the pixel grid coordinates and the sensor model grid coordinates. The ECEF coordinates lying within the pixel grid can be derived using the equations outlined in Sections 3.2 to 3.11. Mapping of the SIDD grids to the projection models is outlined in Section 3.12.

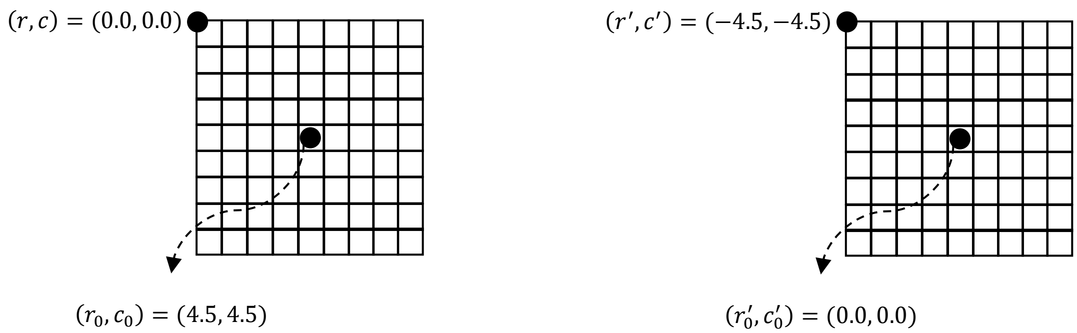
3.1 SIDD Sensor Model Grid

SIDD heavily leverages the *Sensor Independent Complex Image Data Image Projections* specification (Table 1-2) for its projections equations. SIDD projection utilizes a reference point-centered representation of the sensor model grid for projection. This means that there is a translation between pixel grid coordinates {r, c} and sensor model coordinates {r', c'} and distances $\{d_r, d_c\}$ that must be accounted for prior to application of the equations (Figure 3-1).

$$r' = r - r_0$$

$$c' = c - c_0$$

The above equations define the translations to sensor model coordinates {r', c'}.



(a) Pixel Grid (b) Sensor Model Grid

Figure 3-1 Differences between pixel and sensor model grids

Distance within the sensor model grid can now be defined as

$$d_r = \Delta_r * r'$$

$$d_c = \Delta_c * c'$$

Note that because each of the different grid types utilize sample spacing in different units, the above distance computations also result in units based upon the grid type.

SIDD reuses the data types from the SICD specification to promote consistency between the two specifications. Thus particular metadata items which are functions of sensor model coordinate distances, for example, the *TimeCOAPoly* (see Table 4-15) are built from distances $\{d_r, d_c\}$ in the sensor model space. Please review the *Sensor Independent Complex Data Image Projections* and *Sensor Independent Complex Data Design & Implementation* specifications for more details.

3.2 PGD Pixel to ECEF Coordinate Conversion

The conversion of a PGD pixel grid coordinate {r, c} (and thus sensor grid distance $\{d_r, d_c\}$) to an ECEF coordinate $\mathbf{P}_{ECEF}$, {x, y, z}, is shown below.

$$\boldsymbol{P}_{ECEF} = \boldsymbol{P}_{PGD} + d_r * \boldsymbol{R}_{PGD} + d_c * \boldsymbol{C}_{PGD}$$

3.3 ECEF Coordinate to PGD Pixel Conversion

The conversion of an ECEF coordinate $\mathbf{P}_{ECEF}$, {x, y, z}, to a PGD pixel coordinate is shown below.

$$r = r_0 + \frac{(\boldsymbol{P}_{ECEF} - \boldsymbol{P}_{PGD}) \cdot \boldsymbol{R}_{PGD}}{\Delta_r}$$

$$c = c_0 + \frac{(\boldsymbol{P}_{ECEF} - \boldsymbol{P}_{PGD}) \cdot \boldsymbol{C}_{PGD}}{\Delta_c}$$

3.4 GGD Pixel to Geodetic Coordinate Conversion

The conversion of a GGD pixel grid coordinate {r, c} (and thus sensor grid distance {d_r, d_c}) to a geodetic coordinate is shown below. A constant height above the ellipsoid is used and is set from the reference point $\mathbf{P}_{GGD}$. In the equations below, the sample spacing is assumed to be in arc seconds, φ_0 and λ_0, are in decimal degrees and h_0 is in meters.

$$\varphi = \varphi_0 - \frac{d_r}{3600}$$

$$\lambda = \lambda_0 + \frac{d_c}{3600}$$

$$h = h_0$$

3.5 Geodetic Coordinate to GGD Pixel Conversion

The conversion of a geodetic coordinate to a GGD pixel is shown below. Again, a constant height above the ellipsoid is assumed, as well as sample spacing in arc seconds.

$$\mathrm{r} = \mathrm{r}_0 + \frac{3600(\varphi_0 - \varphi)}{\Delta_\mathrm{r}}$$

$$c = c_0 + \frac{3600(\lambda - \lambda_0)}{\Delta_c}$$

3.6 Geodetic to ECEF Coordinate Conversion

The relationship between the WGS-84 ellipsoid model and the ECEF coordinate system is shown below.

$$\mathrm{X} = (R_c + h)\cos(\varphi)\cos(\lambda)$$
$$\mathrm{Y} = (R_c + h)\cos(\varphi)\sin(\lambda)$$
$$\mathrm{Z} = \left(\frac{b^2}{a^2} R_c + h\right)\sin(\varphi)$$

3.7 ECEF Coordinate to Geodetic Coordinate Conversion

The relationship between the ECEF coordinate system, {X, Y, Z}, and the geodetic coordinate system {φ, λ, h} is described below. The four-quadrant inverse tangent (arctangent) function, atan2(Y,X), with range on the interval $[-\pi, \pi]$, is used.

$$\lambda = \mathrm{atan2}(Y, X)$$

$$D_{XY} = \sqrt{X^2 + Y^2}$$

$$\theta = \text{atan2}(a * Z, b * D_{XY})$$

$$\tan \varphi_{i+1} = \frac{Z + e_2^2 b \sin^3 \theta}{D_{XY} - e_1^2 a \cos^3 \theta}$$

$$\tan \theta_{i+1} = (1 - f) \tan \varphi_{i+1}$$

This iterative procedure is terminated when $\left|\tan \varphi_{i+1} - \tan \varphi_i\right| \leq \varepsilon$, where ε is small. The height above the WGS-84 ellipsoid is then found by the following equation:

$$h = \frac{D_{XY}}{cos(\varphi)} - R_C$$

3.8 CGD Pixel to ECEF Coordinate Conversion

The conversion of a CGD grid pixel coordinate {r, c} (and thus sensor grid distance {d_r, d_c}) to an ECEF coordinate {x, y, z}, is shown below.

$$\theta = \frac{d_c}{R_S}$$

$$\boldsymbol{P}_{ECEF} = \boldsymbol{P}_{CGD} + d_r * \boldsymbol{R}_{CGD} + R_S * \sin\theta * \boldsymbol{C}_{CGD} + R_S * (\cos\theta - 1) * \boldsymbol{U'}$$

3.9 ECEF Coordinate to CGD Pixel Conversion

The conversion of an ECEF coordinate, $\boldsymbol{P}_{ECEF}$, to a CGD pixel coordinate {r,c} is shown below.

$$r = r_0 + \frac{(\boldsymbol{P}_{ECEF} - \boldsymbol{P}_{CGD}) \cdot \boldsymbol{R}_{CGD}}{\Delta_r}$$

$$c_c = (\boldsymbol{P}_{ECEF} - \boldsymbol{P}_{CGD}) \cdot \boldsymbol{C}_{CGD}$$

$$c_u = (\boldsymbol{P}_{ECEF} - \boldsymbol{P}_{CGD}) \cdot \boldsymbol{U'}$$

$$\theta = \cot^{-1} \frac{c_u + R_S}{c_c}$$

$$c = c_0 + \frac{R_S \theta}{\Delta_c}$$

3.10 PFGD Latitude and Longitude to Row and Column Conversion

The following polynomials convert latitude and longitude into row and column pixel locations.

$$r = \sum_{m=0}^{M} \sum_{n=0}^{N} c_{m,n} \lambda^m \varphi^n$$

$$c = \sum_{m=0}^{M} \sum_{n=0}^{N} c_{m,n} \varphi^m \lambda^n$$

3.11 PFGD Row and Column to Latitude, Longitude and Height Conversion

The following polynomials convert row and column pixel locations to latitude, longitude and altitude.

$$\lambda = \sum_{m=0}^{M} \sum_{n=0}^{N} c_{m,n} r^m c^n$$

$$\varphi = \sum_{m=0}^{M} \sum_{n=0}^{N} c_{m,n} r^m c^n$$

$$h = \sum_{m=0}^{M} \sum_{n=0}^{N} c_{m,n} r^m c^n$$

3.12 Projection of SIDD data

Projection of SIDD data (image-to-scene and scene-to-image) can be accomplished via the equations outlined in the *Sensor Independent Complex Data Image Projection* document. The key connection is the computation of the R/Rdot contour for a particular pixel grid coordinate {r,c}.

For SIDD pixel grids PGD, GGD, and CGD (PFGD does not support a formal model), the R/Rdot contours are specified as follows:

$$R_{COA}^{TGT} = \left| ARP_{COA}^{TGT} - P_{ECEF} \right|$$

$$Rdot_{COA}^{TGT} = \left(\frac{VARP_{COA}^{TGT}}{R_{COA}^{TGT}} \right) \cdot \left(ARP_{COA}^{TGT} - P_{ECEF} \right)$$

Where P_{ECEF} is defined in the above sections for each grid type. ARP_{COA}^{TGT} and $VARP_{COA}^{TGT}$ are computed as specified in the *Sensor Independent Complex Data Image Projection* document.

4 SIDD Metadata

The purpose of this section is to define the SIDD metadata. The definition of SIDD metadata includes the items below:

- XML primitives
- Groupings
- Complex structures
- Metadata parameter definitions
- Primitive types

The metadata hierarchical structure for SIDD and SICD is XML. The foundation of the SIDD format is constructed from primitive data types. Primitive data types are reusable structures that define the type of data contained within the metadata parameter and are defined in Section

4.1.2 and in the following documentation: http://www.w3.org/TR/xmlschema-2/. A metadata parameter refers to a piece of information, such as sample spacing, that is required for downstream usage of a SIDD product. The parameters are further organized into complex structures. Each complex structure can contain other parameters, complex structures, or both that are linked together by common metadata. The top level complex structures within the SIDD are referred to as groupings to distinguish them from lower level complex structures. The SIDD metadata is organized into groupings centered on exploitation tasks, such as the *Display* grouping. An example of the naming convention and the general layout of the different types is shown in Figure 4-1.

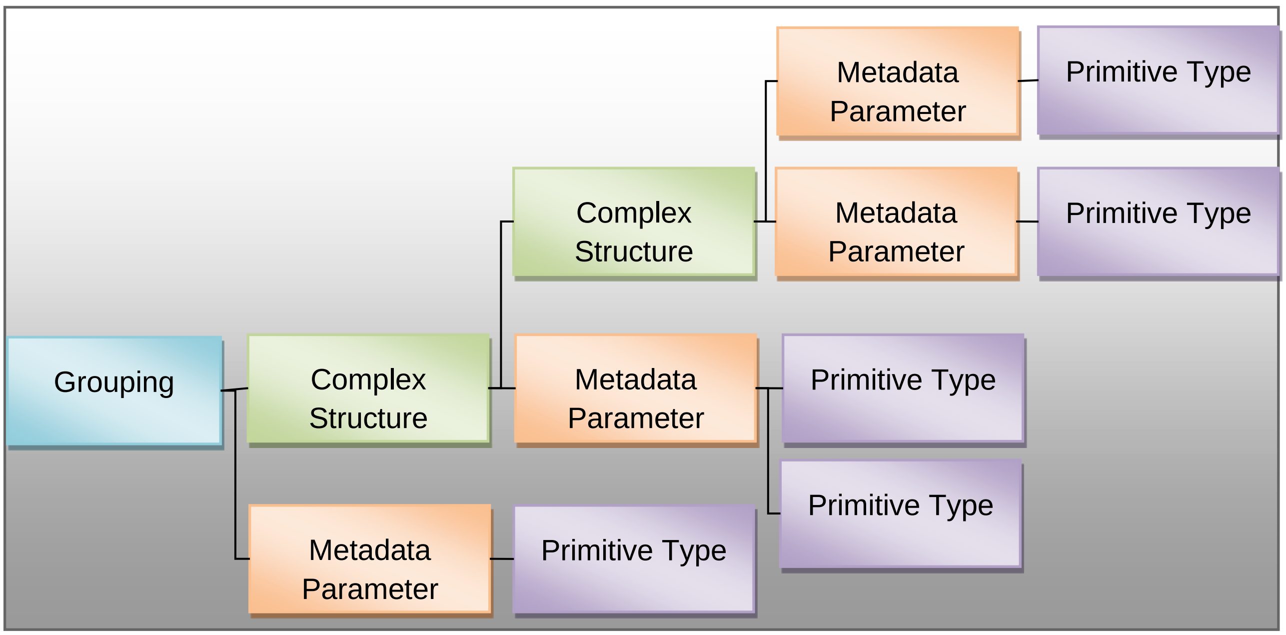


Figure 4-1 Example of Naming Convention and General Schema Layout

4.1 XML Metadata Types

This section provides the following information

- XML schema interpretation
- XML primitive type overview
- XML primitive type definitions

4.1.1 XML Schema Interpretation

The purpose of the next three subsections is to provide instructions for reading the XML schema diagrams provided throughout this document.

4.1.1.1 Required vs. Optional

The schema diagrams use dashed lines for optional parameters or complex structures and solid lines for required parameters or complex structures. The required and optional parameters / complex structures are enforced through both the schema and the documentation. An example of an optional grouping is the *ErrorStatistics* (Section 4.2.7) grouping, and an example of a required grouping is the *ProductCreation* (Section 4.2.1) grouping.

The schema does not enforce conditional parameters or conditional complex structures. Conditional parameters are only enforced through system-specific documentation (profiles).

If a tag is marked as required and its parent tag is marked as optional, then the tag is only required if its parent tag is included. If a profile has a stricter requirement than the SIDD schema or D&I documentation, products created using the profile should follow the profile's requirements.

4.1.1.2 Repeatable

A repeatable type is shown with Y in the 'Repeat' column of the XML Parameters table or within the description of the types tables contained within Section 4.1. An example of a repeatable type is shown Table 4-5 with the *1D_ Poly Type* primitive type. In this example, the type specifies that at least one *Coef* parameter must exist and up to infinity parameters can also exist.

4.1.1.3 Choice

A choice option is identified in the Description column. The schema choice option means that one of the set of parameters that connect to the node must exist. An example of this is the *Filtertype*, where either a *Predefined* or *Custom* filter must be chosen. The Description column contains the words: 'Include exactly one of either Predefined OR Custom'.

4.1.1.4 Units

Units are defined under the type or parameter in the schema layout. Table 4-1 list the units and abbreviations used in this document.

Table 4-1 Unit Abbreviations

Units	Abbreviations
Seconds	s
Meters	m
Meters per second	m/s
Hertz	Hz
Hertz per second	Hz/s
Decimal degrees	dd
Cycles	cyc
Cycles per meter	cyc/m
Cycles per meter squared	cyc/m^2
Radians	rad
Radians per second	rad/s
Samples per second	samples/s
Decibel	dB
Degrees	deg

4.1.2 XML Types Overview

The SICommon Types XML schema defines a set of reusable primitive types that declare XML metadata parameter types. The SICommon Types are the reusable types that are shared between the SICD and SIDD XML schema. There are two basic forms of primitive types: complex and simple. A simple primitive has only one child and can define a specific data type. The simple primitive types are defined in the following documentation: http://www.w3.org/TR/xmlschema-2/. In addition, some of the simple primitive types can be restricted to a specific range of values. For example *Neg180To180* is a parameter that usually refers to an angle that ranges in values from -180 degrees to +180 degrees. The restricted simple primitive types are defined in Table 4-2.

A complex primitive type is used for storing complex information, such as polynomials. An example of a complex primitive type is *Poly1DType* which stores an arbitrary number of coefficients and the order of the polynomial. The complex primitive types are defined in Section 4.1.4.

The SIDD and SICD common schema types are listed in Table 4-3 and Table 4-4 and in Sections 4.1.3 and 4.1.4.

The following table lists the restricted primitive types.

Table 4-2 Restricted Primitive Types

Type	Definition
Neg180To180Type	*Neg180To180Type* restricts inclusively, double values from -180 to 180.
Neg90To90Type	*Neg90To90Type* restricts inclusively, double values from -90 to 90.

4.1.3 Complex SICommon Types

The following table describes the Common XML Types that are used by SIDD.

Table 4-3 Common XML Types		
Type	**Meaning**	**Example XML Parameter**
BOOL	Value is a Boolean type. The Boolean type is used to specify true or false.	Field: SIDD.ExploitationFeatures.Collection.Information.Polarization.Processed Value: “true” Allowed values: “true” or “false”
DBL	Value is a real-valued decimal (base 10) number that when converted to binary format should be converted to a 64 bit floating point type (e.g. IEEE binary64 floating point). It may be a positive or negative value with an optional positive sign (“+”) when positive. The value is represented in the scientific notation (The E23.7 notation) with 16 digits of precision	Field: SIDD.ExploitationFeatures.Collection.Information.CollectionDuration Value: “0.44444 seconds”
ENU	Value can be a string of characters or an integer. There is a certain allowed set of character strings or integer values.	Field: SIDD.ExploitationFeatures.Collection.Information.RadarMode.ModeType Value: “SCANSAR”
INT	Value is an integer. It may be a positive or negative value with an optional positive sign (“+”) when positive.	Field: SIDD.MatchInfo.NumMatchTypes Value: “2”
TXT	Value is a string of characters	Field: SIDD.ProductCreation.ProcessorInformation.Profile Value: “SIDD Design & Implementation, v2.0”
XDT	Value represents the dateTime XML type. The dateTime form is: “YYYY-MM-DDThh:mm:ss.s+” YYYY indicates the year MM indicates the month DD indicates the day “T” indicates the start of the required time section hh indicates hour mm indicates minute ss indicates second s+ indicates fractional seconds * The seconds should be followed by a Z to indicate the time is in UTC (Coordinated Universal Time) *All components are required.	Field: SIDD.ProductCreation.ProcessorInformation.ProcessingDataTime Value: “2008-08-06T20:27:55.123456Z“

XYZ	Identifies a parent tag that consists of a x, y and z component. The values of each component are floating point type, “DBL”. “X” represents the x component “Y” represents the y component “Z” represents the z component	Field: SIDD.Measurement.PlaneProjection.ReferencePoint.ECEF.X Value: 4.444400000000000E01 Field: SIDD.Measurement.PlaneProjection.ReferencePoint.ECEF.Y Value: 4.444400000000000E01 Field: SIDD.Measurement.PlaneProjection.ReferencePoint.ECEF.Z Value: 4.444400000000000E01

The following table describes the SICommon Types that are used by SIDD. The SICommonTypes are the XML parameters that are shared between the SIDD and SICD schemas.

Table 4-4 SICommon Types		
Type	**Meaning**	**Example XML Parameter**
AngleMagnitude	Identifies a parent tag that consists of a required angle and magnitude component. The values of each component are “DBL”	Field: SIDD.ExploitationFeatures.Collection.Phenomenology.Shadow.Angle Value: 7.950000000000000E01 Field: SIDD.ExploitationFeatures.Collection.Phenomenology.Shadow.Magnitude Value: 1.348000000000000E0
LatLon	Identifies a parent tag that consists of a geodetic latitude and longitude component. The values of each component are floating point type, “DBL”. “Lat” represents the latitude point “Lon” represents the longitude point	Field: SIDD.GeoData.ImageCorners.ICP.Lat Attribute: “index = 1:FRFC” Value: 4.444400000000000E01 Field: SIDD.GeoData.ImageCorners.ICP.Lon Attribute: “index = 1:FRFC” Value: 4.444400000000000E01
Parameter	Free format text field that can be used to pass forward generic key/value pair information.	Field: SIDD.ErrorStatistics.AdditionalParm.Parameter Attribute: name = "xxx" name is a descriptive identifier for this information

PolyCoef1D	Identifies a parent tag that consists of a set of coefficients for a one-dimensional polynomial function. The values of each component are floating point type, "DBL". "Coef" represents a coefficient A one-dimensional polynomial input variable 1 (Var1). Variable 1 of order1=M, where M equals the maximum value of the exponent1 attribute. The parent tag POLY will have an order1 attribute. Each component "Coef" will have an exponent1 attribute. The attribute represents the exponents of that coefficient. Zero coefficients may be omitted. Total number of possible coefficients is: (M + 1) $$Z(Var1) = \sum_{m=0}^{M} c_m \cdot (Var1)^m$$	M = 2 Parent Tag: SIDD.Measurement.PlaneProjection.ARPPoly.X Attribute: "order1 = 2" Field:SIDD.Measurement.PlaneProjection.ARPPoly.X.Coef Attribute: "exponent1 = 0" Value: 4.444400000000000E01 Field:SIDD.Measurement.PlaneProjection.ARPPoly.X.Coef Attribute: "exponent1 = 1" Value: 4.444400000000000E01 Field: SIDD.Measurement.PlaneProjection.ARPPoly.X.Coef Atrribute: "exponent1 = 2" Value: 4.444400000000000E01

PolyCoef2D	Identifies a parent tag that consists of a set of coefficients for a two-dimensional polynomial function. The values of each component are floating point type, “DBL”. “Coef” represents a coefficient Two-dimensional polynomial inputs variable 1 (Var1) and variable 2 (Var2). Variable 1 of order1= M, where M equals the maximum value of the exponent1 attribute. Variable 2 of order2= N, where N equals the maximum value of the exponent2 attribute. The parent tag POLY will have an order1 and order2 attribute. Each component “Coef” will have an exponent1 and exponent2 attribute. The attributes represent the exponents of that coefficient. Total number of possible coefficients is: (M+1)*(N+1) $Z(Var1, Var2) = \sum_{m=0}^{M}\sum_{n=0}^{N} c_{m,n} \cdot (Var1)^m \cdot (Var2)^n$ *If a coefficient has a zero value it may be omitted.	M = 2 and N = 1 Parent Tag: SIDD.Measurement.PlaneProjection.TimeCOAPoly Attribute: “order1 = 2”, “order2 = 1” Field: SIDD.Measurement.PlaneProjection.TimeCOAPoly.Coef Attribute: “exponent1 = 0”,”exponent2 = 0” Value: 4.444400000000000E01 Field: SIDD.Measurement.PlaneProjection.TimeCOAPoly.Coef Attribute: “exponent1 = 0”,”exponent2 = 1” Value: 4.444400000000000E01 Field: SIDD.Measurement.PlaneProjection.TimeCOAPoly.Coef Attribute: “exponent1 = 1”,”exponent2 = 0” Value: 4.444400000000000E01 Field: SIDD.Measurement.PlaneProjection.TimeCOAPoly.Coef Attribute: “exponent1 = 1”,”exponent2 = 1” Value: 4.444400000000000E01 Field: SIDD.Measurement.PlaneProjection.TimeCOAPoly.Coef Attribute: “exponent1 = 2”,”exponent2 = 0” Value: 4.444400000000000E01 Field: SIDD.Measurement.PlaneProjection.TimeCOAPoly.Coef Attribute: “exponent1 = 2”,”exponent2 = 1” Value: 4.444400000000000E01

RangeAzimuth	Identifies a parent tag that consists of a geodetic latitude and longitude component. The values of each component are floating point type, “DBL”. “Range” represents the range value “Azimuth” represents the azimuth value	Field: SIDD.ExploitationFeatures.Collection.Information.Resolution.Range Value: 4.444400000000000E-01 Field: SIDD.ExploitationFeatures.Collection.Information.Resolution.Azimuth Value: 4.444400000000000E-01
RC_DBL	Identifies a parent tag that consists of a required row and column component. The values of each component are integers, “DBL”. “Row” represents row “Col” represents column	Field: SIDD.Measurement.PlaneProjection.ReferencePoint.Point.Row Value: 5.000000000000000E02 Field: SIDD.Measurement.PlaneProjection.ReferencePoint.Point.Col Value: 5.000000000000000E02
RC_INT	Identifies a parent tag that consists of a required row and column component. The values of each component are integers, “INT”. “Row” represents row “Col” represents column	Field: SIDD.Measurement.PixelFootprint.Row Value: 500 Field: SIDD.Measurement.PixelFootprint.Col Value: 500
XYZ_POLY	Identifies a parent tag that consists of an x, y and z component. Each component is a PolyCoef1D type. Each parent tag, X,Y,Z will have the order1 attribute. Each component “Coef” will have the exponent1 attribute. “X.Coef” represents a x component coefficient “Y.Coef” represents a y component coefficient “Z.Coef” represents a z component coefficient A one-dimensional polynomial with same input variable 1 (Var1). Total number of possible coefficients is: 3 x (M + 1) $V(Var1) = \begin{bmatrix} X(Var1) \\ Y(Var1) \\ Z(Var1) \end{bmatrix} = \begin{bmatrix} \sum_{m=0}^{M} cx_m \cdot (Var1)^m \\ \sum_{m=0}^{M} cy_m \cdot (Var1)^m \\ \sum_{m=0}^{M} cz_m \cdot (Var1)^m \end{bmatrix}$ *If a coefficient has a zero value it may be omitted.	M = 1 Parent tag: SIDD.Measurement.ARPPoly.X Parent tag: SIDD.Measurement.ARPPoly.Y Parent tag: SIDD.Measurement.ARPPoly.Z All have an attribute: “order1=1” Field: SIDD.Measurement.ARPPoly.X.Coef Attribute: “exponent1 = 0” Value: 4.444400000000000E01 Field: SIDD.Measurement.ARPPoly.X.Coef Attribute: “exponent1 = 1” Value: 4.444400000000000E01 Field: SIDD.Measurement.ARPPoly.Y.Coef Attribute: “exponent1 = 0” Value: 4.444400000000000E01 Field: SIDD.Measurement.ARPPoly.Y.Coef Attribute: “exponent1 = 1” Value: 4.444400000000000E01 Field: SIDD.Measurement.ARPPoly.Z.Coef Attribute: “exponent1 = 0” Value: 4.444400000000000E01 Field: SIDD.Measurement.ARPPoly.Z.Coef Attribute: “exponent1 = 1” Value: 4.444400000000000E01

4.1.4 Expanded Complex Primitive Data Types

This section defines complex primitive types which have expanded structures. For example, *FilterType* has a child called *FilterKernel* which also has additional children.

4.1.4.1 1D_POLYType

The *1D_POLYType* is shown in Table 4-5. It contains an expandable structure for a 1-D polynomial where the order of the polynomial, *M*, is defined by the attribute *order1* along with a number of coefficients based on the order (up to *M+1*). Only non-zero entries of the polynomial need to be specified as parameters *exponent1*.

$$F(x) = \sum_{m=0}^{M} c_m x^m$$

For example, a polynomial named *testpoly* representing the equation

$$x^2 + 3$$

would be represented as:

```
<testpoly order1="2">
        <Coef exponent1="2">1</Coef>
        <Coef exponent1="0">3</Coef>
</testpoly>
```

Table 4-5 1D_POLY Type Definition				
Field Name		**Req /Opt**	**Type**	**Description**
1D_POLY		R		Attributes: order1=”m”, order2=”n”
	Coef	R	1D_POLY	Attribute exponent1=n

4.1.4.2 2D_POLYType

The 2D_POLY*Type* is shown in Table 4-6. The attributes *order1* and *order2* specify the order of the two-dimensional polynomial and are defined as M and N, respectively. The parameters *exponent1* and *exponent2* define the exponents for a given *Coef*. The total number of possible coefficients is (M+1)*(N+1), where only non-zero entries of the polynomial need to be specified. This complex primitive type represents an equation of the following form.

$$F(x,y) = \sum_{m=0}^{M} \sum_{n=0}^{N} c_{m,n} x^m y^n$$

For example, a polynomial named *testpoly*, representing the equation

$$x^2 \cdot y^6 + 3y^2 + 4x + 5$$

would be represented as

```xml
<testpoly order1="2" order2="6">
    <Coef exponent1="2" exponent2="6">1</Coef>
    <Coef exponent1="0" exponent2="2">3</Coef>
    <Coef exponent1="1" exponent2="0">4</Coef>
    <Coef exponent1="0" exponent2="0">5</Coef>
</testpoly>
```

Table 4-6 2D_POLYType Definition

Field Name	Req /Opt	Type	Description
RowColToLat	R		Attributes: order1="m", order2="n"
Coef	R	2D_POLY	Repeatable, 1 to (m+1)*(n+1) Attributes: exponent1="m", exponent2="n"

4.1.4.3 FilterType

The *Filter* is a complex primitive, shown in Table 4-7, and is used to describe filter parameters, either as a predefined or custom filter. Exactly one of either choice must be present.

Table 4-7 FilterType Definition

Field Name	Req/ Opt	Type	Description
FilterName	R	TXT	Name of the filter
FilterKernel	C		Only include one of FilterKernel OR FilterBank. Used for spatially invariant filtering.
Predefined	C		Include exactly one of either Predefined OR Custom.
DatabaseName	C	ENU	Database name of filter to use. Allowed values: "BILINEAR", "CUBIC", "LAGRANGE", "NEAREST NEIGHBOR"
FilterFamily	C	INT	Index specifying the filter family – do not include if a DatabaseName is specified.
FilterMember	C	INT	Index specifying the member of the filter family – do not include if a DatabaseName is specified.
Custom	C		Provide a custom filter kernel to use
FilterCoefficients	R		Attributes: numRows="m", numCols="n"
Coef	R	DBL	Coefficients of the filter kernel used. Attributes: row="x", col="y" Where: x = 0 to m-1 y = 0 to n-1
FilterBank	C		Only include one of FilterKernel OR FilterBank. Used for spatially variant filtering.
Predefined	C		Include exactly one of either Predefined OR Custom.

		DatabaseName		C	ENU	Database name of filter to use, e.g. “BILINEAR”, “CUBIC”, “LAGRANGE”, “NEAREST NEIGHBOR” – do not include if a FilterFamily/Member is used.
		FilterFamily		C	INT	Index specifying the filter family – do not include if a DatabaseName is specified.
		FilterMember		C	INT	Index specifying the member of the filter family – do not include if a DatabaseName is specified.
	Custom			C		Provide a custom bank kernel to use
		FilterCoefficients		R		Attributes: numPhasings=”m”, numPoints=”n”
			Coef	R	DBL	Coefficients of the filter bank is used. Attributes: phasing=”x”, point=”y” Where: x = 0 to m-1 y = 0 to n-1
Operation				R	ENU	Name of filtering operation to be performed. Allowed values: “CORRELATION”, “CONVOLUTION”

4.1.4.4 LookupTableType

The *LookupTableType* is a complex primitive, shown in Table 4-8 and it is used to provide a mapping of values from one input space to another. In the SIDD standard, it is used to identify either pre-defined (via databases, or indices) or custom lookup tables (see Section 4.2.2).

For predefined LUTs, the choices are to supply the *DatabaseName*, or the *RemapFamily* and *RemapMember*.

For custom LUTs, the *LUTInfo* element is a list object which represents the look-up table. The list should be indexed using the input value and the corresponding value at that location in the output. The *size* attribute is used to represent the length of the *LUT* list object. This is required to be consistent with the size of the *LUT*. This is an xs:list object which delimits the values in the list using whitespace.

Table 4-8 LookupTable Definition

Field Name				Req/ Opt	Type	Description
LUTName				R	TXT	Name of the filter
Note: Include exactly one of either Predefined OR Custom						
	Predefined			C		Include exactly one of either DatabaseName or RemapFamily/Member
		DatabaseName		C	TXT	Database name of LUT to use. Refer to program-specific documentation for population guidance. Examples include: PEDF, LINLOG, LINEAR
		RemapFamily		C	INT	Index specifying the Remap family – do not include if a DatabaseName is specified.
		RemapMember		C	INT	Index specifying the member of the Remap family – do not include if a DatabaseName is specified.
	Custom			C		
		LUTInfo		R		Contains the lookup table values for each band Attribute: numLuts=”m”, size=”n”
			LUTValues	R	INT	Entries are space separated

						Attribute: lut="x" where x = 1 to m

4.1.4.5 ReferencePointType

The *ReferencePointType* is shown in Table 4-9. The *XYZType* and *RC_DBL* are complex primitive types within the *ReferencePointType*, and are referenced in Table 4-3. The *ECEF* parameter is contained in the *ReferencePointType* and is an *XYZType*. The ECEF parameter metadata is a *XYZType* and is populated by the *XYZType* instructions (Table 4-2 and Table 4-3). In addition, the *Point* parameter is a *RC_DBL*; please refer to *RC_DBL* for population instructions (Table 4-3).

Table 4-9 ReferencePointType Definition

Field Name	Req/ Opt	Type	Description
ReferencePointType	R		The reference point of the plane
ECEF			The XYZ ECEF reference point (in meters)
X	R	XYZ	X coordinate reference point
Y	R	XYZ	Y coordinate reference point
Z	R	XYZ	Z coordinate reference point
Point			Row and column (in pixels) which maps to the ECEF point
Row	R	RC_DBL	Row component, in DBL precision
Column	R	RC_DBL	Column component, in DBL precision

4.1.4.6 SFA PointType

All SFA *Object*s utilize the *SFA:PointType* as their coordinate encoding mechanism. For a *GeocentricCoordinateSystem X*,*Y*, and *Z* represent ECEF coordinates in meters. For a WGS-84 *GeographicCoordinateSystem X* and *Y* represent latitude and longitude respectively in arcseconds.

Table 4-10 SFA PointType Definition

Field Name	Req/ Opt	Type	Description
PointType	R		The reference point of the plane
X	R	DBL	X coordinate of the plane
Y	R	DBL	Y coordinate of the plane
Z	O	DBL	Z (Height) coordinate of the plane
M	O	DBL	

4.2 XML Metadata Parameter List

The SIDD XML data is arranged to have related parameters grouped together in complex structures. Each complex structure has branches to either other complex structures or parameters. The complex structure stops branching once a parameter has been reached. The parameter is made up of primitives, which declares the data type of the parameter. In addition, the parameter contains the actual metadata associated with the image product.

The section is broken into the top level groupings defined in Table 4-11. The top level groupings are complex structures but will be referred to as groupings to distinguish from lower level complex structures. In each grouping section, the branching layout for each complex structure is displayed. The complex structural layouts start with the highest point in the branch and end with the lowest. The parameters' primitives and definitions are then listed in tables. In addition, a reference is provided to the reusable primitives defined in Sections 4.1.3 and 4.1.4.

Table 4-11 SIDD Schema Layout Paragraph Reference

Grouping	**Section**	**Definition**
ProductCreation	4.2.1	Provides information related to the initial processing of the product including classification, product type, and processor that produced it. This should be populated upon product creation.
Display	4.2.2	Contains information needed to help properly display the product in an exploitation tool. This should be populated upon product creation.
GeoData	**Error! Reference source not found.**	Contains generic and extensible targeting and geographic region information. This should be populated upon product creation.
Measurement	4.2.4	Contains the metadata detailing the projection applied as well as collection metadata necessary for performing measurements. This should be populated upon product creation.
ExploitationFeatures	4.2.5	Contains information that provides aid to an end user in interpreting product phenomenology with regard to the collections. The metadata in this grouping can also be used to generate legends and icons. This should be populated upon product creation.
DownstreamReprocessing	0	The metadata describes the downstream exploitation modifications made to the file such as geometric chipping, resampling, etc. This metadata should be

		populated by the downstream tool making the modifications, such as an Electronic Light Table (ELT). This should be populated upon product creation.
ErrorStatistics	4.2.7	Contains metadata that describes the errors in radar collection parameters, and that is required for propagation of error ellipses to the product. Only one set of error data is included in the SIDD product that reflects the overall product. This should be populated upon product creation.
Radiometric	4.2.8	Contains radiometric information about the product (parameters that enable the conversion of pixel power level to radar reflectivity parameters). See SICD documentation (Table 1-2) for metadata definitions. Only one set of radiometric data is included in the SIDD product that reflects the overall product. This should be populated upon product creation.
MatchInfo	4.2.9	Information about other collections that are matched to the current collection.
Compression	4.2.9	Contains information regarding any compression that has occurred to the image data.
DED	4.2.10	This block describes the Digital Elevation Data when it is included with the SIDD product.
ProductProcessing	4.2.11	Contains an extensible structure for recording processor-specific algorithm information applied during product generation. This should be populated upon product creation.
Annotations	4.2.9	List of annotations for the imagery.

4.2.1 ProductCreation

The *ProductCreation* contains information related to initial processing, classification, and product type. The *ProductCreation* structures are laid out in Table 4-12.

Table 4-12 Product Creation Parameters

Field Name	Req/Opt	Type	Description	Units	Repeat	Attributes
SIDD						
ProductCreation	R		Information related to processor information, classification and product type		N	
ProcessorInformation	R		Required parameter containing basic information about the processor used to create the product.		N	

			Application	R	TXT	Software application name and version number used to create the product. Should be updated for each release.	-	N	
			ProcessingDateTime	R	XDT	Date and Time defined in Coordinated Universal Time (UTC). The seconds should be followed by Z to indicate UTC.	-	N	
			Site	R	TXT	Creation location of the product	-	N	
			Profile	O	TXT	Product specific profile applied during product processing	-	N	
		Classification		R	-	Overall classification of the product	-	N	Please see associated reference and specification for further details. ISMRootNodeAttributeGroup ResourceNodeAttributeGroup SecurityExtension Extensible parameters used to support profile-specific needs related to product security
		ProductName		R	TXT	Output product name defined by the processor	-	N	
		ProductClass		R	TXT	Class of product (top level suite), e.g. Dynamic Image, Amplitude Change Image, Coherent Change Detection, etc.	-		
		ProductType		C	TXT	Information on the type of the product. For products that are part of a suite this refers to the individual co-product (e.g Frame #, Reference, Match, etc.). Omit if a single product suite.	-	N	
		ProductCreationExtension		O	Parameter	Extensible parameters used to support profile-specific needs related to product creation	-	Y	

4.2.2 Display

The *Display* grouping contains information required for proper display of the imagery. The parameters in this block are expected to be utilized in conjunction with a NGA Softcopy Image Processing Standard (SIPS) v2.4 compliant viewer. In addition, the grouping also describes any remaps or compensations applied to the data, as well as, differentiating whether a color remap or monochrome remap was applied to the data. Lookup Tables provided in the NITF image sub-header should be applied before performing any operations in the Display block. Filter and decimation enumerations types are further defined in Section 6. Allowable pixel types are further defined in Section 2.4 of NGA.STND.0025-2_2.0, NITF File Format Description Document.

Table 4-13 Display Parameters

Field Name			Req /Opt	Type	Description	Units	Repeat	Attributes
SIDD								
	Display		R		This block provides information needed to help properly display the product in an exploitation tool		N	
		PixelType	R	ENU	Indicates the pixel type and binary format of the data. Allowed values: “MONO8I”, “MONO8LU”, “MONO16I”, “RGB8LU”, or “RGB24I”	-	N	
		NumBands	R	INT	Number of bands contained in the image Populate with the number of bands present after remapping. For example an 8-bit RGB image (RGB8LU) this should be populated with 3.	-	N	
		DefaultBandDisplay	O	INT	Indicates which band to display by default. Valid range = 1 to NumBands	-	N	
		NonInteractiveProcessing	R	-	Parameters describing the non-interactive processing elements: Product Generation Options (PGO), PGO databases, RRDS generation and RRDS database. For more information, consult the latest version		Y	band=”n” n = 1 to NumBands

			of the SIPS. Image data at this stage is un-processed, except for expansion and compression			
ProductGenerationOptions	R		Performs several key actions on an image to prepare it for necessary additional processing to achieve the desired output product.		N	
BandEqualization	O		Band Equalization ensures that real-world neutral colors have equal digital count values (i.e. are represented as neutral colors) across the dynamic range of the imaged scene.		N	
Algorithm	R	ENU	Allowed values: 1DLUT	-	N	
BandLUT	R	LookupTable		-	Y	Index=”k”
ModularTransferFunctionRestoration	O	Filter	Filter must be no larger than 15x15.	-	N	
DataRemapping	R	LookupTable	Data remapping refers to the specific need to convert the data of incoming, expanded or uncompressed image band data to non-mapped image data.		N	
AsymmetricPixelCorrection	C	Filter	Include for asymmetric data	-	N	
RRDS	R		Creates a set of sub-sampled versions of an image to provide processing chains with quick access to lower magnification values for faster computation speeds and performance.			
DownsamplingMethod	R	ENU	Algorithm used to perform RRDS downsampling. Allowed values: “DECIMATE”, “MAX PIXEL”, “AVERAGE”, “NEAREST NEIGHBOR”, “BILINEAR”, “LAGRANGE” Refer to program-specific documentation for population guidance.	-	N	
AntiAlias	C	Filter	Anti-alias filter used for RRDS generation.	-	N	

			Refer to program-specific documentation for population guidance. Note: Operation = CONVOLUTION			
Interpolation	C	Filter	Interpolation filter used for RRDS generation. Refer to program-specific documentation for population guidance. Note: Operation = CORRELATION	-	N	
InteractiveProcessing	R		Parameters describing the interactive processing component, which comprises seven elements: geometric transformation, band operations, color space transform, alternate color space (ACS) operations, output preparation, an interpolator database and an ICC for file database. For additional information, refer to the latest version of the SIPS. Only those operations necessary for further processing of the product should be enabled.		Y	band=”n” n = 1 to NumBands
GeometricTransform	R		The geometric transform element is used to perform various geometric distortions to each band of image data. These distortions include image chipping, scaling, rotation, shearing, etc.		N	
Scaling	R				N	
AntiAlias	R	Filter	Anti-Alias Filter used for scaling. Refer to program-specific documentation for population guidance. Note: Operation = CONVOLUTION	-	N	
Interpolation	R	Filter	Interpolation Filter used for scaling. Refer to program-specific documentation for population guidance. Note: Operation = CORRELATION	-	N	

				Orientation		R		Parameters describing the default orientation of the product.			
					ShadowDirection	R	ENU	Describes the shadow direction relative to the pixels in the file. Allowed values: “UP”, “DOWN”, “LEFT”, “RIGHT”, “ARBITRARY”	-	N	
			SharpnessEnhancement			R		Must include exactly one of MTFC or MTFE		N	
				ModularTransferFunctionCompensation		C	Filter	Note: If defining a custom filter, it must be no larger than 5x5	-	N	
				ModularTransferFunctionEnhancement		C	Filter	Note: If defining a custom filter, it must be no larger than 5x5	-	N	
			ColorSpaceTransform			O				N	
				ColorManagementModule		R		Parameters describing the Color Management Module (CMM)		N	
					RenderingIntent	R	ENU	Allowed values: “PERCEPTUAL”, “SATURATION”, “RELATIVE”, “ABSOLUTE” where: RELATIVE = Relative colorimetric ABSOLUTE = Absolute colorimetric	-	N	
					SourceProfile	R	TXT	Name of sensor profile in ICC Profile database	-	N	
					DisplayProfile	O	TXT	Name of display profile in ICC Profile database	-	N	
					ICCProfileSignature	O	TXT	Valid ICC profile signature	-	N	
			DynamicRangeAdjustment			R		Specifies the recommended ELT DRA overrides		N	
				AlgorithmType		R	ENU	Algorithm used for dynamic range adjustment Allowed values: “AUTO”, “MANUAL”, “NONE”	-	N	
				BandStatsSource		R	INT	Indicates which band to use in computing statistics for DRA. Valid range = 1 to NumBands	-	N	
				DRAParameters		C		Include DRAParameters if AlgorithmType = AUTO		N	
					Pmin	R	DBL	DRA clip low point. This is the cumulative histogram percentage	-	N	

								value that defines the lower end-point of the dynamic range to be displayed. Range: [0.0000 to 1.0000]			
					Pmax	R	DBL	DRA clip high point. This is the cumulative histogram percentage value that defines the upper end-point of the dynamic range to be displayed. Range: [0.0000 to 1.0000]	-	N	
					EminModifier	R	DBL	The pixel value corresponding to the Pmin percentage point in the image histogram. This is the DRA Parameter “A” from the SIPS table 2.30. Range: [0.0 to 1.0]	-	N	
					EmaxModifier	R	DBL	The pixel value corresponding to the Pmax percentage point in the image histogram. This is the DRA Parameter “B” from the SIPS table 2.30. Range: [0.0 to 1.0]	-	N	
				DRAOverrides		O		Optional block that can be included based on programmatic guidance. Exclude if AlgorithmType = NONE			
					Subtractor	R	DBL	Subtractor value used to reduce haze in the image. Range: [0.0 to 2047.0]	-	N	
					Multiplier	R	DBL	Multiplier value used to brighten the image. Range: [0.0 to 2047.0]	-	N	
			TonalTransferCurve			O	LookupTable	The 1-D LUT element uses one or more 1-D LUTs to stretch or compress tome data in valorous regions within a digital image’s dynamic range. 1-D LUT can be implemented using a Tonal Transfer Curve (TTC) if needed. The TTC database contains various TTCs that can be applied to imagery. The appropriate TTC to apply depends on many factors, including the image content and target application. A TTC is selected	-	N	

			by specifying the Family and Member numbers of the curve. There are 12 families of TTCs: Range = [0, 11] There are 64 members for each family: Range = [0,63]				
DisplayExtension	O	Parameter	Optional additional extensible parameters in key-value form.	-	Y	

4.2.3 GeoData

The GeoData grouping contains information about the targets residing in the product and the geographic coverage of the product. The structural layouts of the groupings are shown in Table 4-14. This complex structure represents a hierarchical decomposition of the area contained within the product. It contains an optional *GeoInfo* for the area, a geodetic *Footprint*, and either information pertaining to the region or a decomposition of the region into subregions. Each *SubRegion* contains the same information as the *GeoInfo* element and may be decomposed in a similar manner. Using this sub-region decomposition may be useful to relate specific security or country identifiers to particular portions of the product's ground coverage.

Table 4-14 GeoData Parameters

Field Name	Req /Opt	Type	Description	Units	Repeat	Attributes
SIDD						
GeoData	R		This block describes the geographic coordinates of the region covered by the image.		N	
EarthModel	R	ENU	Identifies the earth model used for latitude, longitude and height parameters. All height values are Height Above The Ellipsoid (HAE)	-	N	

						Populate with “WGS_84”			
		ImageCorners		R		Parameters apply to image corners of the product projected to the same height as the SCP. These corners are an approximate geographic location that is not intended for analytical use.		N	
			ICP	R	LL	Image Corner Point (ICP) data for the 4 corners in product. ICPs indexed x = 1, 2, 3, 4, clockwise. x = 1: First row, First Column (FRFC)	dd	N	Index = “1:FRFC”
			ICP	R	LL	Image Corner Point (ICP) data for the 4 corners in product. ICPs indexed x = 1, 2, 3, 4, clockwise. x = 2: First row, Last Column (FRLC)	dd	N	Index = “2:FRLC”
			ICP	R	LL	Image Corner Point (ICP) data for the 4 corners in product. ICPs indexed x = 1, 2, 3, 4, clockwise. x = 3: Last row, Last Column (LRLC)	dd	N	Index = “3:LRLC”
			ICP	R	LL	Image Corner Point (ICP) data for the 4 corners in product. ICPs indexed x = 1, 2, 3, 4, clockwise. x = 4: Last row, First Column (LRFC)	dd	N	Index = “4:LRFC”
		ValidData		R		Indicates the full image includes both valid data and some zero filled pixels. Simple convex polygon enclosed the valid data (may include some zero filled pixels for simplification). Vertices in clockwise order.		N	Size = “x” where x = number of vertices in polygon. Number of vertices must be at least 3.
			Vertex	R	LL	Valid data points projected to the ground/surface level. Points may be projected to the same height as the SCP if ground/surface height data is not available. The vertex positions are approximate geographic locations and not intended for analytical use. Vertices indexed n = 1, 2, . . ., NumVertices. Vertices in same order as SIDD.Measurement.ValidData.Vertex.	dd	Y	Index = “1” to “x” x = number of vertices in polygon Number vertices must be at least 3

							-90.0 < Lat < 90.0, -180.0 < Lon < 180.0			
		GeoInfo			O		Parameters describing geographic features Note: the GeoInfo block may be used as a block within itself (see next 6 lines below Desc).		Y	Name = “xxx”, name is a descriptive identifier for this information
			Desc		O	TXT	Used to specify a name and description of a geographic feature.	-	Y	Name = “xxx”, name is a descriptive identifier for this information
			Point		O	LL	Used to specify a single point Range: -90.0 ≤ Lat ≥ 90.0, -180.0 ≤ Lon ≥ 180.0	dd	N	
			Line		O		Used to specify a “linear” feature with connected line segments. The size attribute represents the number of endpoints (NumEndpoints)		N	Size = “x”
				Endpoint	R	LL	Line segment endpoints indexed x = 1, 2, …, NumEndpoints. NumEndpoints ≥ 2	dd	Y	Index = “x”
			Polygon		O		Used to specify a polygon. The size attribute represents the number of endpoints (NumEndpoints)		N	Size = “x”
			Vertex		R	LL	Polygon vertices indexed n = 1, 2…, NumVertices. NumVertices ≥ 3. 1st and last vertices are connected to form the polygon.	dd	Y	Index = “1” to “x” x = number of vertices in polygon Number vertices must be at least 3

4.2.4 Measurement

The *Measurement* grouping encapsulates metadata that is necessary for performing image to geographic measurements. The complex structure layouts are shown in Table 4-15.

Table 4-15 Measurement Parameters

Field Name	Req /Opt	Type	Description	Units	Repeat	Attributes
SIDD	R					
Measurement	R		This block contains the metadata detailing the projection applied as well as collection metadata necessary for performing measurements. Choose exactly one of the conditional projections below.	-	N	
PlaneProjection	C		Planar representation of the pixel grid			
ReferencePoint	R		Describes the reference point of the plane		N	
ECEF	R	XYZ	Reference point in ECEF	m	N	
Point	R	RC_DBL	Reference point in row and column	-	N	
SampleSpacing	R	RC_DBL	Spacing between pixels. Image plane pixel spacing accounting for any scaling/downsampling that has been applied.	m/p	N	
TimeCOAPoly	R	2D_POLY	Time at which center of the aperture for a given pixel coordinate (measured in meters from scene center) in the product occurs	s	N	order1 = “M” order2 = “N”
ProductPlane	R		Plane definition for the product		N	
RowUnitVector	R	XYZ	Unit vector of the plane that is defined to be aligned in the increasing row direction of the product	-	N	
ColUnitVector	R	XYZ	Unit vector of the plane that is defined to be aligned in the increasing column direction of the product	-	N	
PolynomialProjection	C		Polynomial pixel to ground. Only used for sensor systems where the radar geometry parameters are not recorded.			
ReferencePoint	R		Describes the reference point for the geometrical system		N	
ECEF	R	XYZ	Reference point in ECEF	m	N	
Point	R	RC_DBL	Reference point in row and column	-	N	

RowColToLat	R	2D_POLY	Polynomial used to convert from row and column pixel location to latitude. Results is Latitude in decimal degrees	dd, dd/rc, dd/rc^2, dd/rc^3, etc.	N	order1 = “M” order2 = “N”
RowColToLon	R	2D_POLY	Polynomial used to convert from row and column pixel location to longitude. Result is Longitude in decimal degrees	dd, dd/rc, dd/rc^2, dd/rc^3, etc.	N	order1 = “M” order2 = “N”
RowColToAlt	O	2D_POLY	Polynomial used to convert from row and column pixel location to altitude. Result is Altitude above the WGS-84 ellipsoid in meters.	m, m/rc, m/rc^2, m/rc^3, etc.	N	order1 = “M” order2 = “N”
LatLonToRow	R	2D_POLY	Polynomial used to convert latitude and longitude locations into row pixel locations. Result is in Rows	r, r/dd, r/dd^2, r/dd^3, etc.	N	order1 = “M” order2 = “N”
LatLonToCol	R	2D_POLY	Polynomial used to convert latitude and longitude locations into column pixel locations. Result is in Columns	c, c/dd, c/dd^2, c/dd^3, etc.	N	order1 = “M” order2 = “N”
GeographicProjection	C		Geographic mapping of the pixel grid referred to as GGD in the Design and Exploitation document.			
ReferencePoint	R		Describes the reference point for the geographic grid, usually the scene center point.		N	
ECEF	R	XYZ	Reference point in ECEF	m	N	
Point	R	RC_DBL	Reference point in row and column	-	N	
SampleSpacing	R	RC_DBL	Spacing between pixels	arcsec	N	
TimeCOAPoly	R	2D_POLY	Time at which center of the aperture for a given pixel coordinate (measured in meters from scene center) in the product occurs	s	N	order1 = “m” order2 = “n”

		CylindricalProjection			C		Cylindrical mapping of the pixel grid referred to as CGD in the Design and Exploitation document.			
			ReferencePoint		R		Describes the reference point for the geometrical system		N	
				ECEF	R	XYZ	Reference point in ECEF	m	N	
				Point	R	RC_DBL	Reference point in row and column	-	N	
			SampleSpacing		R	RC_DBL	Spacing between pixels	m	N	
			TimeCOAPoly		R	2D_POLY	Time at which center of the aperture for a given pixel coordinate (measured in meters from scene center) in the product occurs	s	N	order1 = “M” order2 = “N”
			StripmapDirection		R	XYZ	Describes the along stripmap direction	-		
			CurvatureRadius		O	DBL	Defines the Radius of Curvature at scene center. If not present, the radius of curvature will be derived based upon the equations provided in Section 3.			
		PixelFootprint			R	RC_INT	Size of the image in pixels	-	N	
		ARPFlag			C	ENU	Flag indicating whether ARP polynomial is based on the best available: Allowed values: “REALTIME” – based on ephemeris at time of collect, “PREDICTED” – based on predicted ephemeris (i.e. pre-collect) or “POST PROCESSED” – Ephemeris has been refined after data collection.	-	N	
		ARPPoly			R	XYZ_Poly	Aperture Reference Point (ARP) polynomial in ECF as a function of time t (variable 1). Time t = 0 at collection start.	m	N	
		ValidData			R		Indicates the full image includes both valid data and some zero filled pixels. Simple convex polygon enclosed the valid data (may include some zero filled pixels for simplification). Vertices in clockwise order. Not needed if valid data is the full rectangle.		N	Size = “x” where x = number of vertices in polygon. Number of vertices must be at least 3.

Vertex	R	RC_INT	Vertices indexed n = 1, 2…, NumVertices. NumVertices ≥ 3. Vertex 1 is determined by (1) minimum row index, (2) minimum column index if 2 vertices with minimum row index, 1st and last vertices are connected to form the polygon. Polygon vertex pixel global row and column index.	dd	Y	Index = "1" to "x" x = number of vertices in polygon Number vertices must be at least 3

4.2.5 *ExploitationFeatures*

The *ExploitationFeatures* structure contains additional metadata parameters needed for advanced exploitation tasks such as creating legends and icons. The complex structures for the *ExploitationFeatures* grouping are shown in Table 4-16.

Table 4-16 Exploitation Parameters

Field Name	Req /Opt	Type	Description	Units	Repeat	Attributes
SIDD	R					
ExploitationFeatures	R		Computed metadata regarding one or more of the input collections and final product	-	N	
Collection	R		Metadata describing the input collections. This block is repeated for each input image.		Y	Identifier = "IID" for the collect.
Information	R		Generic collection information			
SensorName	R	TXT	The name of the sensor	-	N	
RadarMode	R		Radar collection mode			
ModeType	R	ENU	Refers to the collection type. Allowed values = "SPOTLIGHT", "STRIPMAP", "DYNAMIC STRIPMAP", "SCANSAR"	-	N	
ModeID	O	TXT	If the Radar has a mode, fill in with the mode name	-	N	
CollectionDateTime	R	XDT	Collection data and time (UTC). Use the start of the collection time. The	-	N	

								seconds should be followed by a Z to indicate UTC.			
				LocalDateTime		O	XDT	The date and time defined in local time.	-		
				CollectionDuration		R	DBL	The duration of the collection	s	N	
				Resolution		O		The uniformly-weighted resolution (range and azimuth) processed in the slant plane. Half-power (-3dB) width.			
					Range	R	DBL	Resolution in range	m	N	
					Azimuth	R	DBL	Resolution in azimuth	m	N	
				InputROI		O		Region of interest parameter representing portion of input data used to make the derived product. Only include if the product extent represents a ROI from the tasked extent.			
					Size	R	RC_INT	Describes the number of rows and columns extracted from the input.	-	N	
					UpperLeft	R	RC_INT	Describes the upper-left pixel extracted from the input.	-	N	
				Polarization		O		Describes the transmit and receive polarization of the collection		Y	
					TxPolarization	R	ENU	Polarization transmit type Allowed values: “V”, “H”, “RHC”, “LHC”, “OTHER”, “UNKNOWN”, “SEQUENCE”	-	N	
					RcvPolarization	R	ENU	Polarization receive type Allowed values: “V”, “H”, “RHC”, “LHC”, “OTHER”, “UNKNOWN”	-	N	
					RcvPolarizationOffset	O	DBL	Angle from transmit to receive polarization defined at center of aperture. Range: [-180 to 180]	deg	N	
			Geometry			O		Optional parameter that provides key geometry parameters independent of the product processing. All values computed at the center time of the full collection.		N	

				Azimuth	O	DBL	The angle clockwise from north to the line of sight vector, projected into the Earth Geodetic Tangent Plane (EGTP) Range: [0,360)	deg	N	
				Slope	O	DBL	The angle between the Earth Geodetic Tangent Plane (EGTP) normal vector to the line of sight vector, computed at scene center. Range: [0,90]	deg	N	
				Squint	O	DBL	The angle from the platform velocity vector to the line of sight vector, computed at scene center. Left-look is positive, right-look is negative. Also known as the ground plane squint angle. Range: [-180, 180]	deg	N	
				Graze	O	DBL	The angle between the Earth Geodetic Tangent Plane (EGTP) and the line of sight vector. Range: [0, 90]	deg	N	
				Tilt	O	DBL	The angle between the Earth Geodetic Tangent Plane (EGTP) and the cross range vector. Also known as the twist angle. Range: [-180, 180]	deg	N	
				DopplerConeAngle	O	DBL	The angle between the velocity vector and the radar line-of-sight vector. Also known as the slant plane squint angle. Range: [0,180)	deg	N	
				Extension	O	Parameter	Optional parameter for the product complex structure which can be used to extend the metadata supported.	-	Y	
			Phenomenology				All values computed at the center time of the full collection.			
				Shadow	O	ANG_MAG	Describes the phenomenon where vertical objects occlude radar energy. The shadow angle is measured from the increasing row direction to the	deg	N	

							shadow vector. The value reported should represent the smallest angle (least magnitude) between the two vectors. Positive angles represent counter-clockwise rotation from the increasing row direction; negative angles represent clockwise rotation. Angle range: [-180, 180)			
				Layover	O	ANG_MAG	Describes the phenomenon where vertical objects appear as ground objects with the same range/range rate. The layover angle is measured from the increasing row direction to the layover vector. The value reported should represent the smallest angle (least magnitude) between the two vectors. Positive angles represent counter-clockwise rotation from the increasing row direction; negative angles represent clockwise rotation. Angle range: [-180, 180)	deg	N	
				Multipath	O	DBL	Range dependent phenomenon which describes the energy from a single scatter returned to the radar via more than one path and results in a nominally constant direction in ground plane imagery. This field reports the angle of the multi-path, measured from the increasing row direction. The value reported should represent the smallest angle (least magnitude) between the two vectors. Positive angles represent counter-clockwise rotation from the increasing row direction; negative angles represent clockwise rotation. Angle range: [-180, 180)	deg	N	
				GroundTrack	O	DBL	Describe the angle from increasing row direction to the ground track at the center of the image. This field	deg	N	

							reports the angle from increasing row direction to ground track vector at the center of the image. The value reported should represent the smallest angle (least magnitude) between the two vectors. Positive angles represent counter-clockwise rotation from the increasing row direction; negative angles represent clockwise rotation. Angle range: [-180, 180)			
				Extension	O	Parameter	Optional parameter for the product complex structure which can be used to extend the metadata supported.	-	Y	
		Product			R		Metadata regarding the product		Y	
			Resolution		R	RC_DBL	Uniformly-weighted resolution projected into the Earth Geodetic Tangent Plane (EGTP)	m	N	
			Ellipticity		R	DBL	Ellipticity of the 2D-IPR at the ORP, measured in the Earth Geodetic Tangent Plane (EGTP). Ellipticity is the ratio of the IPR ellipse’s major axis to minor axis.	-	N	
			Polarization		R		Describes the processed transmit and receive polarizations for the product		Y	
				TxPolarizationProc	R	ENU	Processed transmit polarization. Allowed values: “V”, “H”, “RHC”, “LHC”, “OTHER”, “UNKNOWN”, “SEQUENCE”	-	N	
				RcvPolarizationProc	R	ENU	Processed receive polarization. Allowed values: “V”, “H”, “RHC”, “LHC”, “OTHER”, “UNKNOWN”	-	N	
			North		O	DBL	Describes the angle from increasing row direction to north at the center of the image. The value reported should represent the smallest angle (least magnitude) between the two vectors. Positive angles represent counter-clockwise rotation from the increasing	deg	N	

			row direction; negative angles represent clockwise rotation. Angle range: [-180, 180)			
Extension	O	Parameter	Optional parameter for the product complex structure which can be used to extend the metadata supported.	-	Y	

4.2.6 *DownstreamReprocessing*

The optional *DownstreamReprocessing* grouping contains information about processing performed on a SIDD product by an exploitation tool. This grouping should not be included in the SIDD metadata during initial product creation; it will only be included when an ELT or other tool performs post-processing on a SIDD product. When any tool performs post-processing on a SIDD product, this grouping will be used by the tool to document the post-processing that occurred.

Table 4-17 DownstreamReprocessing Parameters

Field Name	Req /Opt	Type	Description	Units	Repeat	Attributes
SIDD	R					
DownstreamReprocessing	O		Only used if downstream modification to the product has occurred.	-	N	
GeometricChip	O		Contains information related to downstream chipping of the product. There is only one instance, and the instance is updated with respect to the full image parameters. For example, if an image is chipped out of a smaller chip, the new chip needs to be updated to the original full image corners. Since this relationship is linear, bi-linear interpolation is sufficient to determine an arbitrary chip coordinate in terms of the original full image coordinates. Chipping is typically done using an exploitation tool, and		N	

			should not be done in the initial product creation.			
ChipSize	R	RC_INT	Number of pixels in the chipped product	-	N	
OriginalUpperLeftCoordinate	R	RC_DBL	The chip's upper left corner in the original full image's extent. See 5.1.1	-	N	
OriginalUpperRightCoordinate	R	RC_DBL	The chip's upper right corner in the original full image's extent. See 5.1.1	-	N	
OriginalLowerLeftCoordinate	R	RC_DBL	The chip's lower left corner in the original full image's extent. See 5.1.1	-	N	
OriginalLowerRightCoordinate	R	RC_DBL	The chip's lower right corner in the original full image's extent. See 5.1.1	-	N	
ProcessingEvent	O		Contains information related to downstream processing of the product.		Y	Added each time an exploitation tool performs post-processing
ApplicationName	R	TXT	Application (usually referring to specific exploitation tool and version) which applied a modification	-	N	
AppliedDateTime	R	XDT	Date and time (in UTC) at which the processing was applied	-	N	
InterpolationMethod	O	TXT	Type of interpolation applied to the data.	-	N	
Descriptor	O	Parameter	Descriptor for the processing event.	-	Y	

4.2.7 ErrorStatistics

The optional *ErrorStatistics* grouping will be carried forward from the SICD metadata when available. In the case where there are multiple SICD inputs, the profile (see Section 1.3) will define which should be propagated from the SICD. The top level layout for this grouping can be seen in Table 4-18. For more details, see the *SICD Design & Implementation Description Document* referenced in Table 1-2.

Table 4-18 ErrorStatistics Parameters

Field Name	Req /Opt	Type	Description	Units	Repeat	Attributes
SIDD	R					

	ErrorStatistics					O		Parameters used to compute error statistics within the SICD sensor model.	-	N	
		CompositeSCP				O		Composite error statistics for the Scene Center Point. Slant plane range (Rg) and azimuth (Az) error statistics. Slant plane defined at SCP COA.		N	
			Rg			R	DBL	Estimated range error standard deviation.	m	N	
			Az			R	DBL	Estimated azimuth error standard deviation.	m	N	
			RgAz			R	DBL	Estimated range and azimuth error correlation coefficient.	-	N	
		Components				O		Error statistics by components.		N	
			PosVelErr			R		Position and velocity error statistics for the radar platform.		N	
				Frame		R	ENU	Coordinate frame used for expressing P,V errors statistics. Allowed values: “ECF”, “RIC_ECF”, “RIC_ECI”. Where RIC = Radial, In-Track, Cross-Track. Radial – From earth center through the platform position.	-	N	
				P1		R	DBL	Position coordinate 1 standard deviation.	m	N	
				P2		R	DBL	Position coordinate 2 standard deviation.	m	N	
				P3		R	DBL	Position coordinate 3 standard deviation.	m	N	
				V1		R	DBL	Velocity coordinate 1 standard deviation.	m/sec	N	
				V2		R	DBL	Velocity coordinate 2 standard deviation.	m/sec	N	
				V3		R	DBL	Velocity coordinate 3 standard deviation.	m/sec	N	
				CorrCoefs		R		CorrelationCoefficient parameters		N	
					P1P2	R	DBL	P1, P2 correlation coefficient.	-	N	
					P1P3	R	DBL	P1, P3 correlation coefficient.	-	N	

					P1V1	R	DBL	P1, V1 correlation coefficient.	-	N	
					P1V2	R	DBL	P1, V2 correlation coefficient.	-	N	
					P1V3	R	DBL	P1, V3 correlation coefficient	-	N	
					P2P3	R	DBL	P2, P3 correlation coefficient.	-	N	
					P2V1	R	DBL	P2, V1 correlation coefficient.	-	N	
					P2V2	R	DBL	P2, V2 correlation coefficient.	-	N	
					P2V3	R	DBL	P2, V3 correlation coefficient.	-	N	
					P3V1	R	DBL	P3, V1 correlation coefficient.	-	N	
					P3V2	R	DBL	P3, V2 correlation coefficient.	-	N	
					P3V3	R	DBL	P3, V3 correlation coefficient.	-	N	
					V1V2	R	DBL	V1, V2 correlation coefficient.	-	N	
					V1V2	R	DBL	V1, V3 correlation coefficient.	-	N	
					V2V3	R	DBL	V2, V3 correlation coefficient.	-	N	
				PositionDecorr		O		Platform position error decorrelation function.		N	
					CorrCoefZero	R	DBL	Error correlation coefficient for zero time difference (CC0).		N	
					DecorrRate	R	DBL	Error decorrelation rate. Simple linear decorrelation rate (DCR). Δt = |t2 – t1| CC(Δt) = Min(1.0,Max(0.0,CC0 – DCR*Δt))	1/sec	N	
			RadarSensor			R		Radar sensor error statistics		N	
				RangeBias		R	DBL	Range bias error standard deviation	m	N	
				ClockFreqSF		O	DBL	Payload clock frequency scale factor standard deviation. SF = Δf/f0.	-	N	
				TransmitFreqSF		O	DBL	Transmit frequency scale factor standard deviation. SF = Δf/f0.	-	N	
				RangeBiasDecorr		O		Range bias decorrelation rate		N	
					CorrCoefZero	R	DBL	Error correlation coefficient for zero time difference (CC0).	-	N	
					DecorrRate	R	DBL	Error decorrelation rate. Simple linear decorrelation rate (DCR). Δt = |t2 – t1| CC(Δt) = Min(1.0,Max(0.0,CC0 – DCR*Δt))	1/sec	N	
			TropoError			R		Troposphere delay error statistics.		N	
				TropoRangeVertical		O	DBL	Troposphere two-way delay error for normal incidence standard deviation. Expressed as a range error. ΔR = ΔT x c/2.	m	N	

				TropoRangeSlant		O	DBL	Troposphere two-way delay error for the SCP line of sight at COA standard deviation. Expressed as a range error. ΔR = ΔT x c/2.	m	N	
				TropoRangeDecorr		O		Troposphere bias decorrelation rate		N	
					CorrCoefZero	R	DBL	Error correlation coefficient for zero time difference (CC0).		N	
					DecorrRate	R	DBL	Error decorrelation rate. Simple linear decorrelation rate (DCR). Δt = |t2 – t1| CC(Δt) = Min(1.0,Max(0.0,CC0 – DCR*Δt))	1/sec	N	
			IonoError			R		Ionosphere delay error statistics.		N	
				IonoRangeVertical		O	DBL	Ionosphere two-way delay error for normal incidence standard deviation. Expressed as a range error. ΔR = ΔT x c/2.	m	N	
				IonoRangeRateVertical		O	DBL	Ionosphere two-way delay rate of change for normal incidence standard deviation. Expressed as a range error. ΔRdot = ΔTdot x c/2.	m/sec	N	
				IonoRgRgRateCC		R	DBL	Ionosphere range error and range rate error correlation coefficient.	-	N	
				IonoRangeVertDecorr		O		Ionosphere bias decorrelation rate		N	
					CorrCoefZero	R	DBL	Error correlation coefficient for zero time difference (CC0).	-	N	
					DecorrRate	R	DBL	Error decorrelation rate. Simple linear decorrelation rate (DCR). Δt = |t2 – t1| CC(Δt) = Min(1.0,Max(0.0,CC0 – DCR*Δt))	1/sec	N	
		AdditionalParm				O		Additional user defined errors parameters		N	
			Parameter			R	TXT	Free format field that can be used to include additional parameters.	~	Y	name = "xxx", name is a descriptive identifier for this information

4.2.8 Radiometric

The optional *Radiometric* is defined in the SICD specifications. All elements map pixel intensities to the radiometric parameter. The top level layout for this grouping can be seen in Table 4-19. For more details, see the *SICD Design & Implementation Description Document* referenced in Table 1-2.

Table 4-19 Radiometric Parameters

Field Name	Req /Opt	Type	Description	Units	Repeat	Attributes
SIDD	R					
Radiometric	O		Radiometric calibration parameters.	-	N	
Pixel Power Pwr(row,col) = Real(S(row,col)2) + Imag((S(row,col)**2)**						
NoiseLevel	O		Noise Level Structure	-	N	
NoiseLevelType	R	ENU	Parameter to indicate that the noise power polynomial yields either absolute power level or power level relative to the SCP pixel location. Allowed values: “ABSOLUTE” or “RELATIVE”	-	N	
NoisePoly	R	2D_POLY	Polynomial coefficients that yield thermal noise power (in dB) in a pixel as a function of image row coordinate (variable 1) and column coordinate (variable 2).	dB, dB/m, etc.	N	order1 = “M” order2 = “N”
RCSSFPoly	O	2D_POLY	Polynomial coefficients that yield a scale factor to convert pixel power into RCS (sqm) as a function of image row coordinate (variable 1) and column coordinate (variable 2). Scale factor computed for a target at HAE = SCP_HAE.	m^2, m, 1, 1/m, etc.	N	order1 = “M” order2 = “N”
SigmaZeroSFPoly	O	2D_POLY	Polynomial coefficients that yield a scale factor to convert pixel power to clutter parameter Sigma-Zero (σ_0) as a function of image row coordinate (variable 1) and column coordinate	1, 1/m, $1/m_2$ etc.	N	order1 = “M” order2 = “N”

					(variable 2). Scale factor computed for a clutter cell at HAE = SCP_HAE.			
		BetaZeroSFPoly	O	2D_POLY	Polynomial coefficients that yield a scale factor to convert pixel power to radar brightness or Beta-Zero (β_0) as a function of image row coordinate (variable 1) and column coordinate (variable 2). Scale factor computed for a clutter cell at HAE = SCP_HAE.	1, 1/m, $1/m^2$ etc.	N	order1 = “M” order2 = “N”
		SigmaZeroSFIncidenceMap	O	ENU	Allowed Values: “APPLIED” or “NOT_APPLIED”			
		GammaZeroSFPoly	O	2D_POLY	Polynomial coefficients that yield a scale factor to convert pixel power to clutter parameter Gamma-Zero (γ_0) as a function of image row coordinate (variable 1) and column coordinate (variable 2). Scale factor computed for a clutter cell at HAE = SCP_HAE.	1, 1/m, $1/m^2$ etc.	N	order1 = “M” order2 = “N”
		GammaZeroSFIncidenceMap	O	ENU	Allowed Values: “APPLIED” or “NOT_APPLIED”	-	N	

4.2.9 MatchInfo Parameters

The conditional *MatchInfo* parameters is used when other imaging collections can be matched to the current collection.

Table 4-20 MatchInfo Parameters

Field Name		Req /Opt	Type	Description	Units	Repeat	Attributes
SIDD		R					
	MatchInfo	O		Information about other collections that are matched to the current collection. The current collection is the collection from which this SIDD product was generated	-	N	
Note: The use of Matched Collection Parameters is per program specific implementation. Match Types, Type IDs, and match parameters are defined in the Program Specific Implementation Documentation.							

NumMatchTypes	R	INT	Number of types of matched collections. Match types are indexed for mt = 1 to NumMatchtypes	-	N	
MatchType	R		Block containing information about the match type mt. Block repeated for mt = 1 to NumMatchTypes.		N	index = “mt”
TypeID	R	TXT	Text string identifying the match type. Suggested values = “STEREO”, “MULTI-LOOK”, “MULTI-IMAGE”, “COHERENT”, “GEOLOCATION”, “MULTI-VIEW”	-	N	
CurrentIndex	O	INT	Collection sequence for the current collection. Indicates the number (instance) of the current collection relative to the number of mates in the current imaging window (IW).	-	N	
NumMatchCollections	R	INT	Number of matched collections for this match type. May be set to 0. Matched collections indexed by mc = 1 to NumMatchCollections.	-	N	
MatchCollection	O		Block containing information about match collection mc. Block repeated for mc = 1 to NumMatchCollections		Y	index = “mc”
CoreName	R	TXT	Test string that uniquely identifies the matching collection.	-	N	
MatchIndex	O	INT	Collection sequence index for the match collection	-	N	
Parameter	O	TXT	Relevant match parameter. Attribute name identifies the parameter	-	Y	name = “xxx”

4.2.10 Compression Parameters

The conditional *Compression* parameters is used when the image has been compressed. Note that currently the SIDD specification only supports JPEG 2000 compression. The fields are described in Table 4-21

Table 4-21 Compression Parameters

Field Name	Req /Opt	Type	Description	Units	Repeat	Attributes

SIDD	R					
Compression	C		Contains information regarding any compression that has occurred to the image data. Only include if COMRAT=C8 or M8		N	
J2K	R		Block describing details of JPEG 2000 compression.	-	N	
Original	R					
NumWaveletLevels	R	INT	The default number of wavelet decomposition levels performed per tiles in the original image out of the processors.		N	
NumBands	R	INT	The number of spectral bands in the original image out of the processors	-	N	
LayerInfo	C		Original Layer Information. The following fields repeat for all layers in (0, 1, …, numLayers-1). The default number of layers per tile in original image out of the original processor.		N	numLayers = “M”
Layer	R		Layer Index Number indicates the number of layer being described. Attribute index = “N”, where N = 0 to M-1 and M = numLayers	-	Y	index= “N”
Bitrate	R	DBL	The bit rate target associated with the layer. It may happen that the bit rate was not achieved due to data characteristics. Note: for JPEG 2000 numerically lossless quality, the bit rate for the final layer is an expected value, based on performance. 1	-	Y	
Parsed	C		Conditional fields that exist only for parsed images		N	
NumWaveletLevels	R	INT	The default number of wavelet decomposition levels performed per tile in the parsed image.	-	N	
NumBands	R	INT	The number of spectral bands in the parsed image.	-	N	
LayerInfo	C		Parsed Layer Information. The following fields repeat for all layers in		N	numLayers = “M”

Field Name	Req /Opt	Type	Description	Units	Repeat	Attributes
			(0, 1, …, numLayers-1). The default number of layers per tile in parsed image.			
Layer	R		Layer Index Number indicates the number of layer being described. Attribute index = “N”, where N = 0 to M-1 and M = numLayers	-	Y	index = “N”
Bitrate	R	DBL	The bit rate target associated with the layer. It may happen that the bit rate was not achieved due to data characteristics. Note: for JPEG 2000 numerically lossless quality, the bit rate for the final layer is an expected value, based on performance.	-	Y	

4.2.11 Digital Elevation Data Parameters

The conditional *DigitalElevationData* parameters are used when the when a DEM is included with the product. The fields are described in Table 4-22

Table 4-22 DigitalElevationData Parameters

Field Name	Req /Opt	Type	Description	Units	Repeat	Attributes
SIDD						
DigitalElevationData	O		This block describes the Digital Elevation Data when it is included with the SIDD product.		N	
GeographicCoordinates	R		Describes the Local Geographic Coordinate system linking row/column to the absolute geographic coordinate (lat/long)			
LongitudeDensity	R	DBL	Pixel ground spacing in E/W direction that is the number of pixels or element intervals in 360 degrees.	-	N	
LatitudeDensity	R	DBL	Pixel ground spacing in N/S direction that is the number of pixels or element intervals in 360 degrees.	-	N	

			ReferenceOrigin	R	LL	Northwest corner Latitude/Longitude – product NW corner	dd	N	
		Geopositioning		R		Describes the absolute coordinate system to which the data is referenced.		N	
			CoordinateSystemType	R	ENU	Coordinate System Type Value: “GCS” or “UTM” Units: GCS: decimal degrees (dd) UTM: meters (m)	-	N	
			GeodeticDatum	R	TXT	Geodetic Datum Value: “World Geodetic System 1984”	-	N	
			ReferenceEllipsoid	R	TXT	Reference Ellipsoid Value: “World Geodetic System 1984”	-	N	
			VerticalDatum	R	ENU	Vertical Datum Value: “Mean Sea Level”	-	N	
			SoundingDatum	R	ENU	Sounding Datum Code Value: “Mean Sea Level”	-	N	
			FalseOrigin	R	INT	Z values false origin Suggested value = “0”	-	N	
			UTMGridZoneNumber	C	INT	Grid zone number, required for UTM, not include for GCS. (4 character field) Allowed values: [1, 60] for northern hemisphere [-1, -60] for southern hemisphere. Signed UTM Zone = {[(AOI Mid-Longitude + 180.0) / 6.0] truncate fractionpart} + 1 Where: -180.0 ≤ Mid-Lon < +180.0	-	N	
		PositionalAccuracy		R		Describes the horizontal and vertical point and regional information for the DED			
			NumRegions	R	INT	Number of positional accuracy regions (number follows). 1 – accuracy information applies to the entire image segment	-	N	
			AbsoluteAccuracy						

				Horizontal	R	DBL	Absolute Horizontal accuracy for the region	m	Y	
				Vertical	R	DBL	Absolute Vertical accuracy for the region	m	Y	
			PointToPointAccuracy							
				Horizontal	R	DBL	Point-to-point Horizontal accuracy for the region	m	Y	
				Vertical	R	DBL	Point-to-point Vertical accuracy for the region	m	Y	
		NullValue			O	INT	Value to indicate that no data is available at a point. Default value is -32767	-	N	

4.2.12 ProductProcessing

The optional *ProductProcessing* grouping contains free parameters to allow the product developer to define product and implementation-specific parameters that describe the “algorithm-specific” processing done to create the detected image product. The complex structures for the grouping are shown Table 4-23.

Table 4-23 ProductProcessing Parameters

Field Name				Req /Opt	Type	Description	Units	Repeat	Attributes
SIDD				R					
	ProductProcessing			O		Metadata describing algorithm-specific processing options. Refer to program documentation for population guidance		N	
		ProcessingModule		R	ProcessingModuleType	Required processing module to track the name and any parameters associated with the algorithms used to produce the SIDD.	-	Y	
			ModuleName	R	Parameter	Required parameter containing the name of the algorithm used in processing the product.	-	N	
			ModuleParameter	C	Parameter	Optional switch parameter associated with the algorithm used in the processing the product. Product must	-	Y	

						contain either the ModuleParameter or ProcessingModule			
			ProcessingModule	C	ProcessingModuleType	Optional switch parameter that is a repeatable structure within itself to create an algorithm as a subset of another algorithm. Product must contain either the ModuleParameter or ProcessingModule		Y	

4.2.13 Annotations

OpenGIS Simple Feature Access (SFA) is an ISO standard (19125) for describing simple features in a spatial reference system. The feature representation is limited to objects like points, curves, polygons, surfaces, etc. This standard is considered a profile for the Geographic information – Spatial schema (ISO 19107:2003). In addition, this representation has a direct mapping for geospatial databases provided in SQL Call-Level Interface (SQL/CLI) (ISO/IEC 9075-3:2003).

Annotations are described using ISO Standard 19125 definitions. The ISO standard provides the full definition of these geometrical objects; therefore, it is not repeated within the SIDD D&I document.

SIDD provides a direct mapping in XML of the SFA. The SFA XML objects, along with their SIDD textual descriptions, define an annotation which maps directly to common geospatial databases. In addition, SFA is simple enough such that SIDD producers and exploiters, whether they are ELTs, libraries, or engineers, can read the definition and understand the annotation without requiring a complex interpretation engine.

The main components of the SFA are geometrical objects, a spatial reference system, and a measure reference system. Geometrical objects (*Object*) provide a mapping between the SIDD textual description of the annotation and the representation in 2-, 3-, or 4-space. For SIDD, the SFA implementation is limited to a 3-dimensional geocentric representation or a 2-dimensional geographic representation. The spatial reference system (*SpatialReferenceSystem*) identifies 2 or 3-dimensional coordinate space that the data lies in (See Section 9, Well-known Text Representation of Spatial Reference System, of OGC 06-103r3). The measure references system (*MeasureReferenceSystem*) defines an optional 4th dimension for the coordinate space. This 4th dimension is not permitted in SIDD, but it is has been modeled in XML schema for completeness of the SFA representation.

The SFA annotation representation in SIDD is shown in Table 4-24 and maps the SFA objects to the textual description of the annotation (*Identifier*). This provides a direct mapping of an object or collection of objects to an identifier.

Use of SFA annotations in SIDD XML does not prohibit other forms of annotation supported by the file format specifications, like CGM within NITF graphics segments. Where possible, objects identified in those ancillary annotation formats should be duplicated within the SIDD XML as SFA *Objects*.

Table 4-24 Annotation Parameters

Field Name	Req /Opt	Type	Description	Units	Repeat	Attributes
SIDD	R					
Annotation	O				Y	
Identifier	R	TXT	Descriptor for the object(s) that this annotation represents.	-	N	
SpatialReferenceSystem	O	ReferenceSystemType	This is the geospatial reference system for the annotation. SIDD does not currently support different annotation reference systems. This is assumed to be WGS-84. SIDD assumes that all annotation objects lay within the SFA-defined WGS-84 *GeographicCoordinateSystem* when only two dimensions are used, and the *GeocentricCoordinateSystem* when three dimensions are used.	-	N	
projectedCoordinateSystem						
geographicCoordiateSystem			When only two dimensions are used, all annotation objects lay within the SFA-defined WGS-84 *GeographicCoordinateSystem*			
geocentricCoordiateSystem			When three dimensions are used, all annotation objects lay within the SFA-defined WGS-84 *GeocentricCoordinateSystem*			
Object	R	AnnotationObjectType	The geometrical representation of the list of objects that constitute the annotation. Must choose one of the options below.	-	Y	

						Annotations are described using ISO Standard 19125 definitions. The ISO standard provides the full definition of these geometrical objects; therefore, it is not repeated within the SIDD D&I.			
			Point	C	PointType	Table 1-3, Reference 3			
			Line	C	LineType	Table 1-3, Reference 3			
			LinearRing	C	LinearRingType	Table 1-3, Reference 3			
			Polygon	C	PolygonType	Table 1-3, Reference 3			
			PolyhedralSurface	C	PolyhedralSurfaceType	Table 1-3, Reference 3			
			MultiPolygon	C	MultiPolygonType	Table 1-3, Reference 3			
			MultiLineString	C	MultiLineStringType	Table 1-3, Reference 3			
			Multipoint	C	MultiPoint	Table 1-3, Reference 3			

All SFA *Object*s utilize the *SFA:PointType* as their coordinate encoding mechanism. For a *GeocentricCoordinateSystem X*, *Y*, and *Z* represent ECEF coordinates in meters. For a WGS-84 *GeographicCoordinateSystem X* and *Y* represent latitude and longitude respectively in arcseconds.

5 User Exploitation

The purpose of this section is to describe basic operations that can be done to a SIDD product. Included in this section is the procedure for chipping a SIDD product.

5.1.1 Chipping

The purpose of this section is to describe the procedure for relating a chipped image to its original full product SIDD. The chipping supports three linear operations; translation, rotation, and scaling. Once a chipping operation has been done, it is necessary to continuously map the newly formed chip coordinates to the full original image coordinates; this ensures that all capabilities on the original full image product are also supported on the chip image product. To enable the correct mapping, the coordinates of the chipped image product in terms of the original full image product coordinates must be recorded. For the purposes of chipping, all pixel coordinates refer to the center of the pixel.

Figure 5-1 shows a chipped product of chip size cRows and cCols relative to the full image product. The chip has been rotated, translated and scaled. The corners are recorded in full image coordinates as $\{R_1,C_1\}$ through $\{R_4,C_4\}$, the corresponding chip coordinates are listed below these values. The chip coordinate {r,c} can be related to the original full image chip coordinate {R,C} through bi-linear interpolation.

The bi-linear interpolation method is developed for the rows below, it is then listed for both the rows and columns following Figure 5-1.

The unknown value, R, is estimated from the four known corner coordinates,R_1 through R_4, the matrix form of bi-linear interpolation is below. The unknown value, C, is estimated in a similar manner.

$$R = \begin{bmatrix} 1-u & u \end{bmatrix} \begin{bmatrix} R_1 & R_2 \\ R_4 & R_3 \end{bmatrix} \begin{bmatrix} 1-v \\ v \end{bmatrix}$$

$$u, v \in [0,1]$$

The above equation can be re-written as:

$$R = R_1 + (R_4 - R_1)u + (R_2 - R_1)v + (R_1 + R_3 - R_2 - R_4)uv$$

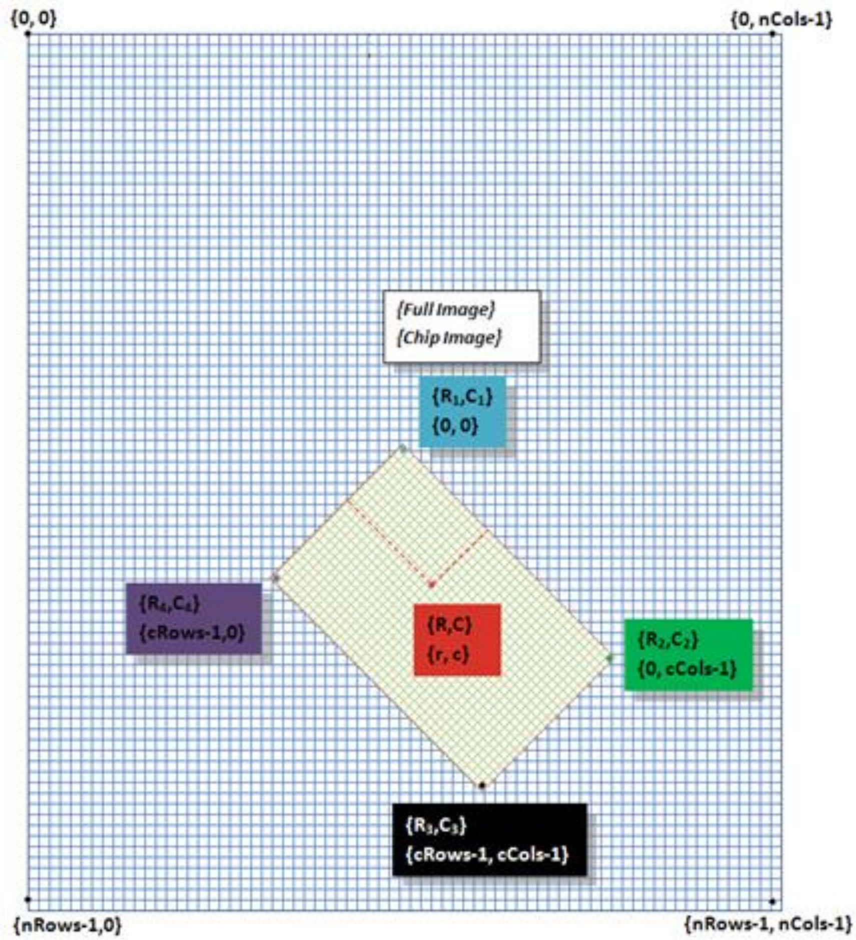


Figure 5-1 Chipping Diagram

The steps for computing the original full image coordinates from the chipped product are outlined below.

Step 1: Normalize the chip coordinates

$$u \equiv \frac{r}{cRows - 1}, v \equiv \frac{c}{cCols - 1}$$

Step 2: Compute original full image row coordinate bi-linear coefficients

$$\begin{aligned} A_r &= R_1 \\ B_r &= R_4 - R_1 \\ D_r &= R_2 - R_1 \\ F_r &= R_1 + R_3 - R_2 - R_4 \end{aligned}$$

Step 3: Compute original full image column coordinate bi-linear coefficients

$$\begin{aligned} A_c &= C_1 \\ B_c &= C_4 - C_1 \\ D_c &= C_2 - C_1 \\ F_c &= C_1 + C_3 - C_2 - C_4 \end{aligned}$$

Step 3: Compute the full image row and column coordinate

$$R = A_r + uB_r + vD_r + uvF_r$$

$$C = A_c + uB_c + vD_c + uvF_c$$

6 Display Calculations

The following tables represent common mathematical definitions for the enumeration types used in displaying data.

6.1 Filter Type Enumerations

Table 6-1 Enumeration Types for *FilterType*	
Enumeration Type	**Definition**
NEAREST NEIGHBOR	Magnification through nearest neighbor has historically been referred to as replication. Under this technique any coordinate which falls within the pixel boundaries obtains the same values as that pixel. The magnification factor is d in both x and y. d>0 $$g(x,y) = f(round\left(\frac{x}{d}\right), round(\frac{y}{d}))$$
BILINEAR	Bilinear interpolation for a magnification factor of d in both the x and y direction is accomplished with the equations below. $$x_1 = floor\left(\frac{x}{d}\right)$$ $$x_2 = ceiling\left(\frac{x}{d}\right)$$ $$y_1 = floor\left(\frac{y}{d}\right)$$ $$y_2 = ceiling\left(\frac{y}{d}\right)$$ $$g(x,y) = \left[\left(x_2 - \frac{x}{d}\right) \ \left(\frac{x}{d} - x_1\right)\right]\begin{bmatrix} f(x_1,y_1) & f(x_1,y_2) \\ f(x_2,y_1) & f(x_2,y_2) \end{bmatrix}\begin{bmatrix} \left(y_2 - \frac{y}{d}\right) \\ \left(\frac{y}{d} - y_1\right) \end{bmatrix}$$
LAGRANGE	Lagrange decimation is the standard interpolation method specified in the SIPS documentation. The Lagrange interpolation uses a 4x4 region about the pixel of interest when determining the new value. Review Section 2.3.5 of the SIPS document.

6.2 DecimationMethod Enumerations

Table 6-2 Enumeration Types for *DecimationMethodType*	
Enumeration Type	**Definition**
NEAREST NEIGHBOR	Decimation by a factor d in both the x and y directions by the nearest neighbor method requires that the value at the output is computed by rounding the new pixel location (x,y) to the nearest integer pixel that was in the original image. $$g(x,y) = f(round(dx), round(dy))$$
BILINEAR	Bilinear interpolation for a decimation factor of d in both the x and a y direction is accomplished with the equations below. $$x_1 = floor(dx)$$ $$x_2 = ceiling(dx)$$ $$y_1 = floor(dy)$$ $$y_2 = ceiling(dy)$$ $$g(x,y) = [(x_2 - dx)\ \ (dx - x_1)] \begin{bmatrix} f(x_1, y_1) & f(x_1, y_2) \\ f(x_2, y_1) & f(x_2, y_2) \end{bmatrix} \begin{bmatrix} (y_2 - dy) \\ (dy - y_1) \end{bmatrix}$$

MAX PIXEL	For max pixel decimation, the max pixel in the region near the new pixel is chosen. The decimation factor in x and y is d. The strategy shown is for MONO type data. The max pixel strategy used for RGB24I and RGB8LU is addressed in the SIPS document. $$g(x,y) = -\infty$$ $$x_1 = floor\left(d\left(x - \frac{1}{2}\right)\right)$$ $$x_2 = ceiling\left(d\left(x + \frac{1}{2}\right)\right)$$ $$y_1 = floor\left(d\left(y - \frac{1}{2}\right)\right)$$ $$y_2 = ceiling\left(d\left(y + \frac{1}{2}\right)\right)$$ For(k = x_1:1:x_2)
	    For(m = y_1:1:y_2)
	        $g(x,y) = max\big(g(x,y), f(k,m)\big)$
	    End
	End

LAGRANGE	Lagrange decimation is the standard interpolation method specified in the SIPS documentation. The Lagrange interpolation uses a 4x4 region about the pixel of interest when determining the new value. Review Section 2.3.5 of the SIPS document.

7 ExploitationFeatures Calculations

The purpose of this section is to provide definitions for the angle metadata defined in the *ExploitationFeaturesType* grouping. In addition to the definitions, derivations are provided for each angle defined in the grouping.

7.1 Definitions

Table 7-1 defines the variables used in the derivations. The figures following the table diagram these angles and variables..

Table 7-1 Variables & Angles

Variables	Definitions	Units
ψ	Grazing Angle	Degrees
ψ_0	Slope Angle	Degrees
ϕ_s	Doppler Cone Angle	Degrees
ϕ_g	Ground Plane Squint Angle	Degrees
$\mathbf{P_a}$	Antenna Position in ECEF coordinates	Meters
$\mathbf{V_a}$	Antenna Velocity in ECEF coordinates	Meters per second
$\mathbf{P_o}$	Scene Center Point in ECEF coordinates	Meters
$\mathbf{Z_g}$	Earth Tangent Plane Normal in ECEF coordinates	Unitless
$\widehat{\ }$	Indicates a vector of unit magnitude	N/A
λ	Latitude at Scene Center Point	Decimal Degrees
φ	Longitude at Scene Center Point	Decimal Degrees
$\hat{\boldsymbol{r}}$	Unit Vector in increasing rows, in ECEF coordinates	Unitless
$\hat{\boldsymbol{c}}$	Unit Vector in increasing columns, in ECEF coordinates	Unitless
θ_r	CCW rotation angle of output product	Degrees
$\rho_{r,s}$	Slant Plane resolution in the range direction	Meters
$\rho_{c,s}$	Slant Plane resolution in the azimuth direction	Meters
$\rho_{r,g}$	Ground Plane resolution in the row direction	Meters
$\rho_{c,g}$	Ground Plane resolution in the column direction	Meters

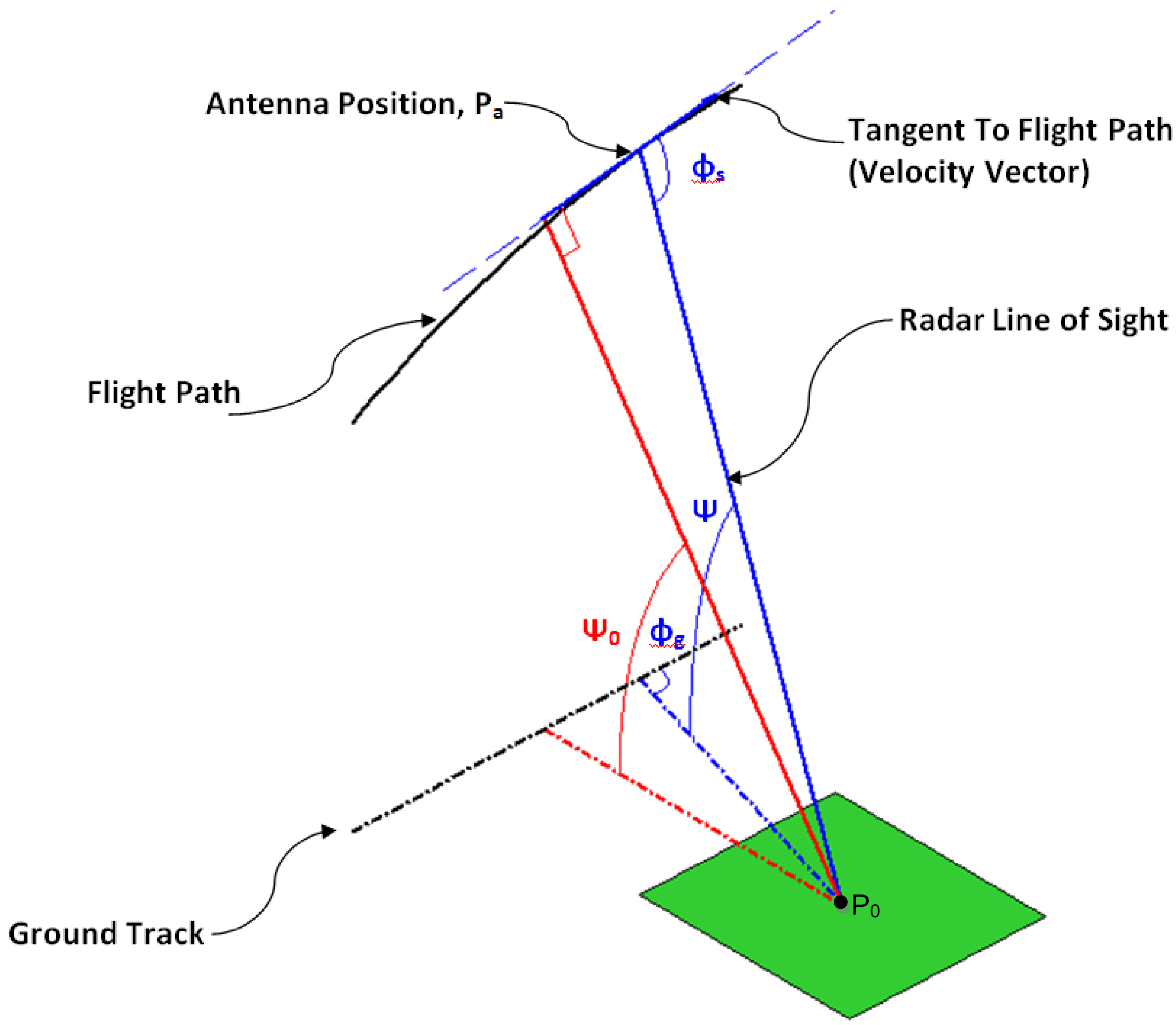


Figure 7-1 Three-Space Angle Definition Diagram

7.2 Slant Plane Definition

To simplify the derivations, it is necessary to define the slant plane. The slant plane is a plane that contains the radar line-of-sight vector and the instantaneous velocity vector. For convenience, the normal of this plane always points away from the earth.

$$\widehat{\boldsymbol{X}}_s = \frac{\boldsymbol{P}_a - \boldsymbol{P}_o}{|\boldsymbol{P}_a - \boldsymbol{P}_o|}$$

$$\widehat{\boldsymbol{n}} = \frac{\widehat{\boldsymbol{X}}_S \times \boldsymbol{V_a}}{\left|\widehat{\boldsymbol{X}}_S \times \boldsymbol{V_a}\right|}$$

$$\widehat{\boldsymbol{Z}}_S = \boldsymbol{sgn}(\boldsymbol{P_o} \cdot \widehat{\boldsymbol{n}})\widehat{\boldsymbol{n}}$$

$$\widehat{\boldsymbol{Y}}_S = \widehat{\boldsymbol{Z}}_S \times \widehat{\boldsymbol{X}}_S$$

7.2.1 Image Plane Definition

The image plane normal is defined below.

$$\hat{\boldsymbol{z}} = \hat{\boldsymbol{r}} \times \hat{\boldsymbol{c}}$$

7.3 Image Angle

Image angles are measured from the direction of increasing rows, which runs across the first column of pixels. This is off the $\hat{\boldsymbol{r}}$ vector toward the $\hat{\boldsymbol{c}}$ vector. The four quadrant arc-tangent function should be used throughout these computations. Positive angles are counter-clockwise (CCW) and negative angles are clockwise (CW), ranging from -180 to 180.

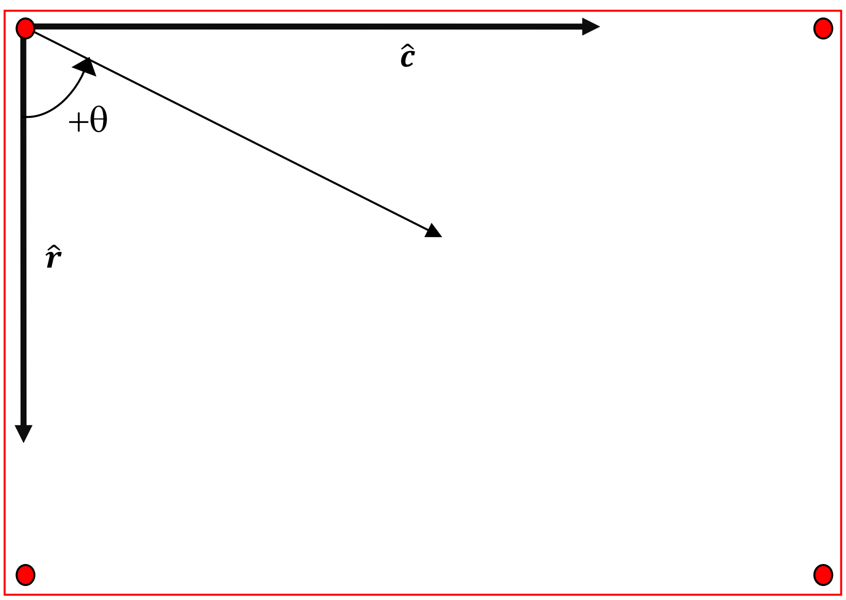


Figure 7-2 Image Angle Diagram

7.4 ExploitationFeatures

This section contains the derivations for the angles contain in the *ExploitationFeatures* grouping.

7.4.1 Polarization Angle

The polarization angle is defined from the *SICD PolarizationHVAnglePoly* evaluated at the center of aperture reference time.

7.5 Geometry

This section contains the geometry parameters independent of product processing.

7.5.1 Azimuth Angle

The azimuth angle indicates the radar line-of-sight vector on the earth. This is angle is measured clockwise from north.

$$\widehat{\boldsymbol{E}} = \widehat{\boldsymbol{N}} \times \widehat{\boldsymbol{U}}$$

$$\theta_A = atan2\left(\widehat{\boldsymbol{E}} \cdot \widehat{\boldsymbol{X}}_{\boldsymbol{s}}, \widehat{\boldsymbol{N}} \cdot \widehat{\boldsymbol{X}}_{\boldsymbol{s}}\right)$$

7.5.2 Slope Angle

Angle between the earth geodetic tangent plane (EGTP) and the slant plane (sometimes referred to as the broadside grazing angle).

$$\psi_0 = \cos^{-1}\left(\widehat{\boldsymbol{Z}}_{\boldsymbol{s}} \cdot \widehat{\boldsymbol{Z}}_{\boldsymbol{g}}\right)$$

7.5.3 Doppler Cone Angle

The Doppler Cone Angle is the angle between the velocity vector and the radar line-of-sight vector (see Figure 7-1).

$$\phi_s = \cos^{-1}\left(-\widehat{\boldsymbol{X}}_{\boldsymbol{s}} \cdot \widehat{\boldsymbol{V}}_{\boldsymbol{a}}\right).$$

7.5.4 Squint

The ground plane (or exploitation) squint angle is the angle between the velocity vector and the radar line-of-sight vector measured in a geocentric plane orthogonal to the ECEF vector $\mathbf{P}_a$.

$$\widehat{\boldsymbol{Z}}_{\boldsymbol{p}} = \frac{\boldsymbol{P}_a}{|\boldsymbol{P}_a|}$$

$$\boldsymbol{X}'_{\boldsymbol{s}} = \widehat{\boldsymbol{X}}_{\boldsymbol{s}} - \left(\widehat{\boldsymbol{X}}_{\boldsymbol{s}} \cdot \widehat{\boldsymbol{Z}}_{\boldsymbol{p}}\right)\widehat{\boldsymbol{Z}}_{\boldsymbol{p}}$$

$$\boldsymbol{V}'_{\boldsymbol{a}} = \boldsymbol{V}_{\boldsymbol{a}} - \left(\boldsymbol{V}_{\boldsymbol{a}} \cdot \widehat{\boldsymbol{Z}}_{\boldsymbol{p}}\right)\widehat{\boldsymbol{Z}}_{\boldsymbol{p}}$$

$$\phi_g = \cos^{-1}\left(-\widehat{\boldsymbol{X}}'_{\boldsymbol{s}} \cdot \widehat{\boldsymbol{V}}'_{\boldsymbol{a}}\right)$$

7.5.5 Grazing Angle

The Grazing angle is the angle between the earth geodetic tangent plane (EGTP) and the line-of-sight vector.

$$\psi = \sin^{-1}(\widehat{\boldsymbol{X}}_s \cdot \widehat{\boldsymbol{Z}}_g)$$

7.5.6 Tilt Angle

The tilt angle (also known as the twist angle) is the angle between the earth geodetic tangent plane (EGTP) and the cross range vector.

$$\eta = \tan^{-1}\left(\frac{\widehat{\boldsymbol{Z}}_g \cdot \widehat{\boldsymbol{Y}}_s}{\widehat{\boldsymbol{Z}}_g \cdot \widehat{\boldsymbol{Z}}_s}\right)$$

7.6 Phenomenology

This section contains the phenomenology related to both the geometry and the final product processing.

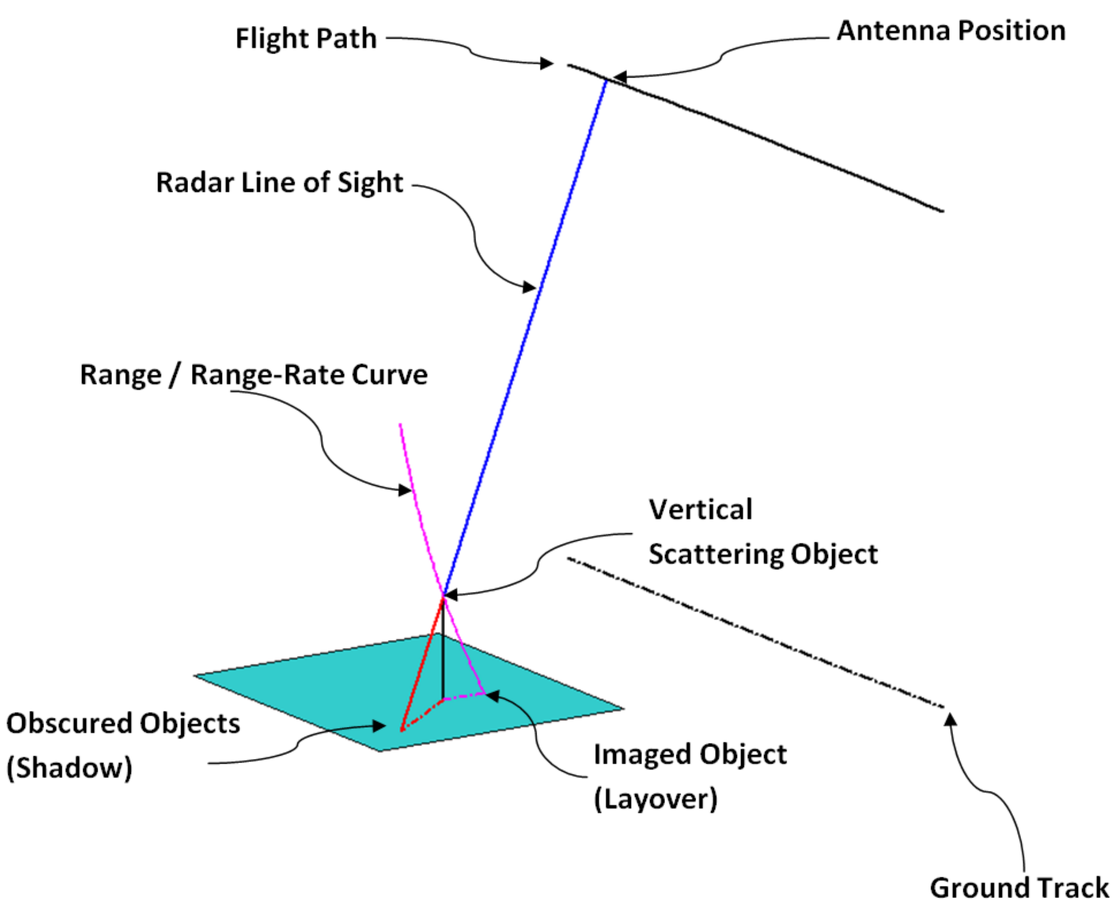


Figure 7-3 Phenomenology Diagram

7.6.1 Shadow

Shadow is an area in an image which is obscured by large vertical objects. The shadow vector derivation is shown below. The shadow angle is measured from the increasing row direction to the output plane projected Shadow Vector. Positive angles are CCW and negative angles are CW.

$$\boldsymbol{S} = \widehat{\boldsymbol{Z}}_g - \frac{\widehat{\boldsymbol{X}}_s}{\widehat{\boldsymbol{X}}_s \cdot \widehat{\boldsymbol{Z}}_g}$$

$$\boldsymbol{S}' = \boldsymbol{S} - \frac{\boldsymbol{S} \cdot \hat{\boldsymbol{z}}}{\widehat{\boldsymbol{Z}}_s \cdot \hat{\boldsymbol{z}}} \widehat{\boldsymbol{Z}}_s$$

$$\theta_S = atan2(\hat{\boldsymbol{c}} \cdot \boldsymbol{S}', \hat{\boldsymbol{r}} \cdot \boldsymbol{S}')$$

The shadow magnitude is then

$$S = \sqrt{\boldsymbol{S}' \cdot \boldsymbol{S}'}$$

7.6.2 Layover

Layover is the phenomenon in which vertical objects appear as ground objects with same range/range-rate. The layover vector derivation is shown below. It assumes that the range/range-rate circles are nominally linear over the length of the ambiguity. The layover angle is measured from the increasing row direction to the output plane projected Layover Vector. Positive angles are CCW and negative angles are CW.

$$\boldsymbol{L} = \hat{\boldsymbol{z}} - \frac{\widehat{\boldsymbol{Z}}_s}{\widehat{\boldsymbol{Z}}_s \cdot \hat{\boldsymbol{z}}}$$

$$\theta_L = atan2(\hat{\boldsymbol{c}} \cdot \boldsymbol{L}, \hat{\boldsymbol{r}} \cdot \boldsymbol{L})$$

The layover magnitude is then

$$L = \sqrt{\boldsymbol{L} \cdot \boldsymbol{L}}$$

7.6.3 North Direction

The north direction points toward the north pole and is defined at the scene center point. The computation is shown below. The north direction angle is measured from the increasing row direction to the output plane projected North Direction Vector. Positive angles are CCW and negative angles are CW.

$$\widehat{\boldsymbol{N}} = \begin{bmatrix} -\sin\varphi\cos\lambda \\ -\sin\varphi\sin\lambda \\ \cos\varphi \end{bmatrix}$$

$$\boldsymbol{N}' = \widehat{\boldsymbol{N}} - \frac{\widehat{\boldsymbol{N}} \cdot \hat{\boldsymbol{z}}}{\widehat{\boldsymbol{Z}}_{\boldsymbol{s}} \cdot \hat{\boldsymbol{z}}} \widehat{\boldsymbol{Z}}_{\boldsymbol{s}}$$

$$\theta_N = atan2(\hat{\boldsymbol{c}} \cdot \boldsymbol{N}', \hat{\mathbf{r}} \cdot \boldsymbol{N}')$$

7.6.4 Up Direction

The up direction is also referred to as $\widehat{\boldsymbol{Z}}_{\mathbf{g}}$, which is normal to an earth geodetic tangent plane. This specific plane is a plane passing through the scene center point and is parallel to a plane that is tangent to the WGS-84 ellipsoid at the geodetic values φ, λ, for the scene center point. The computation is shown below.

$$\widehat{\boldsymbol{Z}}_{\boldsymbol{g}} = \boldsymbol{U} = \begin{bmatrix} \cos\varphi\cos\lambda \\ \cos\varphi\sin\lambda \\ \sin\varphi \end{bmatrix}$$

7.6.5 Multi-Path

Multi-path, or multi-bounce, is a phenomenon in which energy from a single scatter returns to the radar via more than one path. This is a range dependent phenomenon and results in a nominally constant direction in the image plane. The multi-path angle is measured from the increasing row direction to the output plane projected Multi-Path Vector. Positive angles are CCW and negative angles are CW.

The multi-path vector is computed below.

$$\boldsymbol{M} = \widehat{\boldsymbol{X}}_{\boldsymbol{s}} - \frac{\widehat{\boldsymbol{X}}_{\boldsymbol{s}} \cdot \hat{\boldsymbol{z}}}{\widehat{\boldsymbol{Z}}_{\boldsymbol{s}} \cdot \hat{\boldsymbol{z}}} \widehat{\boldsymbol{Z}}_{\boldsymbol{s}}$$

The multi-path angle is computed in the standard fashion.

$$\theta_M = atan2(\hat{\boldsymbol{c}} \cdot \boldsymbol{M}, \hat{\boldsymbol{r}} \cdot \boldsymbol{M})$$

7.6.6 Ground Track (Image Track) Angle

The image track angle is the projection of the velocity vector into the image plane. The ground track (image track) angle is measured from the increasing row direction to the output plane projected Ground Track (Image Track) Vector. Positive angles are CCW and negative angles are CW.

$$\boldsymbol{T} = \boldsymbol{V_a} - (\boldsymbol{V_a} \cdot \hat{\boldsymbol{z}})\hat{\boldsymbol{z}}$$

$$\theta_T = atan2(\hat{\boldsymbol{c}} \cdot \boldsymbol{T}, \hat{\boldsymbol{r}} \cdot \boldsymbol{T})$$

8 Product Resolution

Output plane product resolutions are defined in the row and column directions and can be computed from the slant plane resolutions and collection geometry.

$$\rho_{r,g} = \sqrt{\kappa_{r1}\rho_{r,s}^2 + \kappa_{r2}\rho_{c,s}^2}$$

$$\rho_{c,g} = \sqrt{\kappa_{c1}\rho_{r,s}^2 + \kappa_{c2}\rho_{c,s}^2}$$

Where

$$\kappa_{r1} = \cos^2\theta_r \sec^2\psi + (\sin^2\theta_r \tan\psi \tan\eta - \sin 2\theta_r \sec\psi)\tan\psi \tan\eta$$

$$\kappa_{r2} = \sin^2\theta_r \sec^2\eta$$

$$\kappa_{c1} = (\sin^2\theta_r \sec\psi - \sin 2\theta_r \tan\psi \tan\eta)\sec\psi + \cos^2\theta_r \tan^2\psi \tan^2\eta$$

$$\kappa_{c2} = \cos^2\theta_r \sec^2\eta$$

The rotation angle is defined below:

$$\boldsymbol{X_g} = \hat{\boldsymbol{X}}_{\boldsymbol{s}} - \left(\hat{\boldsymbol{X}}_{\boldsymbol{s}} \cdot \hat{\boldsymbol{z}}\right)\hat{\boldsymbol{z}}$$

$$\theta_r = -atan2\left(\hat{\boldsymbol{c}} \cdot \boldsymbol{X_g}, \hat{\boldsymbol{r}} \cdot \boldsymbol{X_g}\right)$$

9 Acronym List

Table 9-1 Acronyms	
Acronym	**Definition**
ARP	Aperture Reference Point
BE	Basic Encyclopedia
CCW	Counter-clockwise
DRA	Dynamic Range Adjustment
D&I	Design and Implementation Description Document
ECEF	Earth Centered, Earth Fixed Coordinate
EGTP	Earth Geodetic Tangent Plane
ELT	Electronic Light Table
GGD	Geodetic Gridded Display
IERS	International Earth Rotation Service
PGD	Planar Gridded Display
ROI	Region of Interest
RRDS	Reduced Resolution Datasets
SAR	Synthetic Aperture Radar
SFA	Simple Feature Access
SICD	Sensor Independent Complex Data
SIDD	Sensor Independent Derived Data
SIPS	Softcopy Image Processing Standard
UTC	Universal Time Coordinate
XML	eXtensible Markup Language